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Tongue Segmentation Using Active Contour Model

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Abstract. Tongue is an organ of the human body for tasting sense. Healthy conditions can be known from observation of the surface tongue by an expert. Before analyzing the tongue, feature extraction process is needed to segment the tongue from image, so it is possible to develop an application that can segment the tongue image from opened mouth image. This research uses Canny Edge Detection and Active Contour method. Canny Edge Detection is used to find the edges of tongue. This method has four steps: Smoothing Gaussian Filter, Finding Gradients, Non-maximum Suppression, and Hysteresis Thresholding. After finding the tongue edge, Active Contour Model will be generating energy that can pull into edges curve that is already defined and cropping that to produce tongue image. Testing result of this research yield an accuracy rate of 75%, by which from all 40 tongue images, 30 are successfully segmented.

1. Introduction

Detection image of human organs is widely developed in the computer technology, especially the technology of image processing software. Several studies of organ detection system have been widely developed, such as iris detection, ear detection, face detection, and tongue detection. The tongue is an organ in the human body which has very important role in human survival. Tongue has a very detailed pathological of its surface and has a different contours of each individual. Figure 1 shows the image of a human tongue.

Figure 1. Image of Human Tongue

It is difficult to segment an object from the image which is reveal central part of face (mouth area). Because not only tongue but also lips, teeth, mouth itself, and others object are the objects of mouth area. The problem of this image segmentation is how to get the tongue among other objects in that mouth area.

One of the model usually used for the image segmentation is Active Contour Model [1][2]. Active contour model, also called snakes, is a curve that is used to trace the boundary object of image. This

model is a contour detection model that able to locate accurately. This model can be used to segment an image by adjusting the contours and the edges, which is separate the object with others around it.

One of the previous study about tongue segmentation is discussed by [3], a study applying Active Contour Model that able to segment the tongue. In this study, the color image of middle face converted into grayscale image, the separating the tongue object from others object around it using thresholding. Active Contour model is applied on last process to obtain a complete image of the tongue [4]. Other research which focuses on tongue image as the object is a [5] research, adaboost method is applied to find tongue location, then color cancellation is used to clear the area around mouth and tongue. Active Contour Model is used in the final stage to produce a complete image of the tongue. This study used 300 test data of mouth area image, 282 successfully segmented image or has a success rate of over 90%.

2. Data Collecting
This research data is taken from Biometric Research Center website, Hongkong. The data of tongue image is provided into a sample database image of the tongue [5]. There are 12 samples of tongue image which is provided by the Biometric Research Center website. That sample images are given show the mouth with tongue clean condition.

3. Methods
The development of active contour models for tongue segmentation through this following steps: (1) conversion of color images to grayscale, (2) Canny edge detection, and (3) the implementation of active contour models at the end of the process. The first process will be applied in this study is grayscale because it can help to do binary image process in canny edge detection as the second process. The first thing to do is take the input color image then convert it into grayscale image. Every pixel on color images are summed and then divided by three as shown in Equation (1), in order to obtain an intensity values for grayscale images. This result will be used for the next step, canny edge detection [6].

$$S = \frac{R+G+B}{3} \tag{1}$$

Where,

S = value of grayscale;
R = value of red;
G = value of green;
B = value of blue;

Next, apply the canny method to detect the image edges. Canny method has four steps, consist of smoothing (Gaussian filter), finding gradient, non-maximum suppression and thresholding. It is possible if all data images have some noise on it. Noise can make the system doing something wrong when do edge detection. Therefore, the first step should be smoothed by using a Gaussian filter. The essence of the Gaussian filter is the standard deviation with the value of σ = 1.4 is shown in equation (2).
Equation (2) is a 5 x 5 convolution matrix Gaussian filter, with σ=1.4 :

$$g(x,y) = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 4 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \tag{2}$$

Basically, Canny algorithm for finding point of edge on grayscale image area with strong intensity contrasts, this area founded by using image gradient. The gradient of each pixel image has been applied by Sobel operator. The second step is to estimate the gradient in the x and y directions. This is shown in Equation (3) and (4).

$$K_{GX} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \tag{3}$$

$$K_{GY} = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} \tag{4}$$

Where,
KGX : sobel x filter
KGY : sobel y filter.

The edge can be obtained as distance using Pythagoras in equation (5). Gradient for x axis was symbolized as Gx while gradient for y axis as Gy.

$$|G| = \sqrt{G_x^2 + G_y^2} \tag{5}$$

Where,
G : the value of image gradient
Gx : the value of gradient for x axis
Gy : the value of gradient for y axis.

The image that has large gradient value often show quite clearly edges, but that condition may cause it is can not show exactly where the edges are. To determine the actual edges, the edges must be determined and stored as shown in Equation (6).

$$\theta = \arctan \frac{|G_y|}{|G_x|} \tag{6}$$

Where θ shows the value of the angle for edge position.

In the third step conversion of the blurred edges will be done, then sharper edges will be obtained. Basically this is done by keeping all local maxima in the gradient image and delete everything else.

By implementing energy-minimizing function, starting with the placement of deformable objects curve, snake energy find out the point image which has the most minimum energy with equation (7), it will make a curve locate to that point. In the end of the process, deformable curve will occupy the boundary of the defined object in that image, so information about the points of deformable curve can be determined.

Snake can be implemented as these following formula:

$$E_{snake} = \int_0^1 E_{snake}(V(s))ds = \int_0^1 E_{int}(V(s)) + E_{image}(V(s)) + E_{con}(V(s))ds \tag{7}$$

Where,
$E_{int}(V(s))$: internal energy
$E_{image}(V(s))$: image forces
$E_{con}(V(s))$: external energy

Snake energy is formulated from three types of energy, in the form of internal energy, external energy, and the image force. The function α (s) and β (s) in equation (8) affects the snake performance, such as membranes and thin container.
Internal energy is defined in this function:

$$E\text{int} \; = (\alpha(s)\,|\,vs\,(s)\,|^2 \; + (\beta\,(s)\,|\,vss\,(s)\,|^2\,)\,/\,2 \tag{8}$$

Where,
α(s)   : stretching function
β (s)   : bending function

In the image force, there will use three types of functions, namely line, edge and terms are defined in equation (9).

$$Eimage = Wline + Wedge\,Eedge + Wterm\,Eterm \tag{9}$$

Where,
Eline : line functional energy
Eedge : edge functional energy
Eterm : termination functional energy

Image force can be considered as a style on the image that will attract deformable curve to the desired feature. Line functional is the simplest kind of image force. Functional line was centered on the intensity of the image itself. Line functional defined in equation (10).

$$Eline \; = I\,(x,\,y) \tag{10}$$

Line functional will determine where are deformable curve would be located, if the value of the coefficient is positive then the deformable curve will locate toward the dark line, otherwise deformable curve will be locate to the bright line. Edge functional used to pull deformable curve toward a corner and is defined in equation (11).

$$Eedge \; = -\,|\,\Delta I\,(x,\,y)\,|^2 \tag{11}$$

Some of the external energy to be used in equation (12) and (13). Spring energy can be formulated as follows:

$$Ex \; = -k\,(l-l_0\,) \tag{12}$$

where k is a constant value of boundary, l is the distance of contraction or extension spring, and lo is the distance of spring relaxation.
Repulse energy can be defined as:

$$Ex \; = 1/\,d^{\,2} \tag{13}$$

where d is the distance to a particular location.

4. Experiment Result and Analysis
Percentage (%) as the experiment result can be defined through equation (14):

$$percentage\;(\%)\;=\;\frac{Number\;of\;image\;category}{number\;of\;all\;testing\;image}\;x\;100\;\% \tag{14}$$

From the percentage calculation using equation (14), 75% of percentage is obtained from all the tongue segmentation image, 70% of percentage is obtained from primary data, and 80% from the secondary data.

This research use 40 test images for the experiment and produce the result as follows:

    a.   30 of the test images are successfully segmented;

    b.   14 of the primary test images are successfully segmented;

    c.   16 of the secondary test images are successfully segmented;

    d.   10 of the test images are unsuccessfully segmented;

Based on the experiment results, the software can be successfully run as the test planning that already define before. From the scenario experiment, a conclusion that show the test images (noisy image and non-noisy image) which is can accurately segmented or not will be obtained. The test images are used must be clearly images, it means the image does not have other objects besides that tongue itself because its can disturb when entered the edge detection process. The distance when test images are taken also determine the success of segmented or not, if the distance exceeds from the mouth area, other objects such as a mustache or beard would be captured and it may affect when entered the edge detection process, it means the edge tongue will not be detected. Configuration of Double thresholding also affect the final result of segmentation, the configuration of upper 30 and lower 10 do not produce too much and thick edge so the result is quite accurate. Otherwise the configuration of upper 15 and lower 5 produces very large and thick edge that it disturbs the segmentation process, it may affect the end result (inaccurate result).

5. Conclusions

1. Tongue Segmentation Software that implements Active Contour Model using mouth area image (as the center part of face) has been successfully developed.
2. This developed software is able to segment human tongue. The accuracy rate shows how successful the experiment to be done and it is obtained from 40 test images, they are: 75% for all the tongue segmentation image, 70% from primary data, and 80% from the secondary data.
3. The test images which have noise or other objects (besides tongue) will affect the edge detection process, it may make the image cannot segmented.

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