Jihva Parikshan Using Image Processing

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Disease evaluation based on analysis of the tongue is a simple approach to examining body health in Indian Ayurveda and TCM (Traditional Chinese Medicine). However, "JihvaParikshan" (Tongue Diagnosis) is not much practiced in modern-day western medicine because the process is manual and thus human–error-prone during analysis. One of the main aims of this project is to bridge the gap between traditional and modern western medicine practices by automating the tongue analysis process. We are using advances in digital image processing to automatically analyze and characterize differences in tongue features. It is a non-invasive method for disease classification and causes almost no cost for carrying out the analysis and mapping of bodily conditions. Various techniques used for digital image processing are compared to conclude which method gives more accurate results. Changes in tongue color, coating, contour, and geometry may suggest physical or mental ailments, which help us determine the well-being of an individual and analyze the progress of a disease. We've used a sequential technique for processing tongue images to improve the quality of segmentation. We achieved promising experimental results by applying this method to a database of tongue images that we collected. Disease diagnosis using the reflex zones of the tongue is carried out by processing tongue images of patients with the help of the MATLAB program. Otsu thresholding and Watershed segmentation methods are used to classify the processed images according to different parameters. The next step forward in tongue diagnosis using image processing would be analyzing real-time patient images.

Keywords: Image Processing, Watershed segmentation, Otsu Thresholding, MATLAB, Tongue Diagnosis

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1. Introduction

Disease prediction based on tongue condition is the most important component in TCM and ancient Ayurveda practices. Disease classifications are done based on the analysis of the affected reflex zone of the tongue. To classify diseases and their types by evaluating the tongue conditions automatically rather than performing them manually, as seen in traditional medical practices, we propose a computerized tongue diagnosis method. This project aims at eliminating the subjective and qualitative characteristics of traditional tongue diagnosis practices and concluding the mapping relationships between tongue appearances and diseases using MATLAB programming. [2]

The tongue has many relationships and connections with our body, both with the internal organs, energy channels, and body meridians. It is very crucial and consequential during testing and for confirming diseases. A person's overall health condition can easily be mapped to their tongue conditions. Tongue and pulse evaluation are two of the most important and basic diagnostic practices in traditional Chinese medicine and Indian Ayurveda. [7]

Both techniques are used to derive a conclusion about the patient's condition and affected diseases, which helps to plan the treatment. It is very easy to comprehend and process information from tongue interpretation as it is less subjective than pulse diagnosis. Tongue diagnosis is more meridian and organ-specific than pulse analysis. It helps to classify localized diseases better when compared to other conventional practices. The tongue will reveal the depth and nature of body imbalances. It is not much affected by short-term influences such as nervousness, which happens in pulse diagnosis. So, disease predictions are easier using tongue examinations. [7]

Disease progress could be tracked easily by mapping the relationship between the reflex zones of the tongue and body organs.

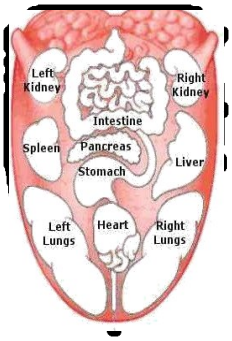


Fig 1: Reflex zones of Tongue [7]

2. Methodology

Images are gathered either from a database of affected and healthy patients or directly from real-time images of the patients. Image segmentation is carried out based on various parameters like color, shape, lesions formed, the thickness of the coating on the tongue, and so on. This image is further evaluated based on size, shapes, margins, and surfaces. Computerized analysis of the tongue is carried out by detailed feature extraction. Based on the condition of the image acquired, the output is displayed. Dividing an image into multiple parts is done by using the image segmentation process. Image segmentation is generally used to determine other relevant information or objects in digital images. There are several methods to perform image segmentation.

2.1 Pre-processing of Tongue Images

Pre-processing of tongue images is carried out with the following steps:

2.1.1 Re-sizing of image

Imagine re-sizing of input images from the database is first carried out to do proper tongue analysis. We can downsize and also up-size an image using scaling factors in MATLAB. Image re-sizing is done in such a way that ROI (Region of Interest) from the tongue is highlighted to evaluate a particular disease.

2.1.2. Contrast Enhancement

Image enhancement on sample images is done by altering the greyscale levels and their original color. It has been widely used in many applications of image processing where the subjective quality of the image is important for human interpretation. Contrast is an important factor in any subjective evaluation of image quality.

RGB to L*a*b* conversion

CIELAB; a color space is a nonlinear transformation of primary color (Red, Green, Blue) where the Euclidean distance between two hues is equal to their perceptual distances (for distances less than ~10 units). Algorithms that operate on color images often generate adequate results in CIELAB. We can convert the RGB image to the L*a*b* color space in MATLAB using its inbuilt function.

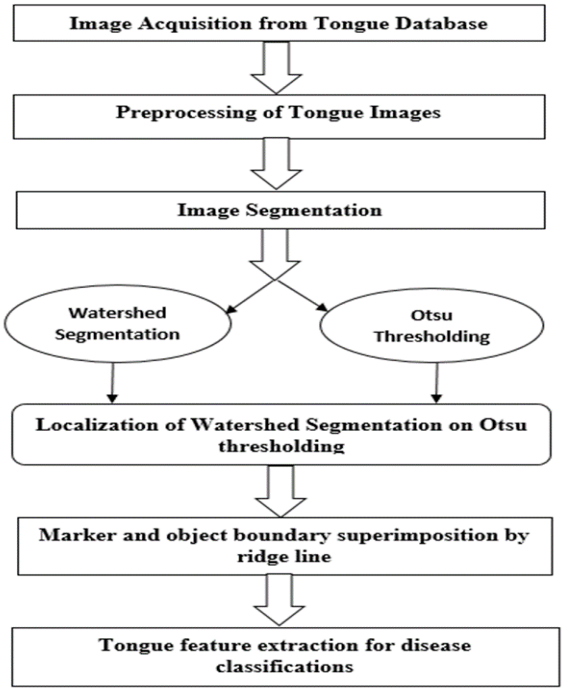


Fig 2.1. Flowchart of methodology

2.2. Segmentation Methods

Image segmentation is the technique of splitting a digital image into multiple segments. Its main aim is to make image analysis easier and faster by dividing it into smaller fragments with certain pixel values. It is widely done using either of the two methods:

i. Otsu Thresholding
ii. Watershed Algorithm

2.2.1 Otsu Thresholding

The Otsu thresholding method carries out iteration of all the possible threshold values. It then calculates a measure of spread for the pixel levels on each side of the threshold, the background pixel, and the foreground pixels. The objective of this step is to find the threshold value where the sum of foreground and background spreads is at its minimum.

$$\mu_T = \sum_{i=0}^{L-1} iP_i,\ \mu_t = \sum_{i=0}^{t} iP_i,\ \mu_0 = \frac{\mu_t}{w_0},\ \mu_1 = \frac{\mu_T - \mu_t}{1 - \mu_0},$$

Fig. 2.2. Otsu thresholding Equation [12]

The algorithm for the computation of the Otsu threshold value is as follows:

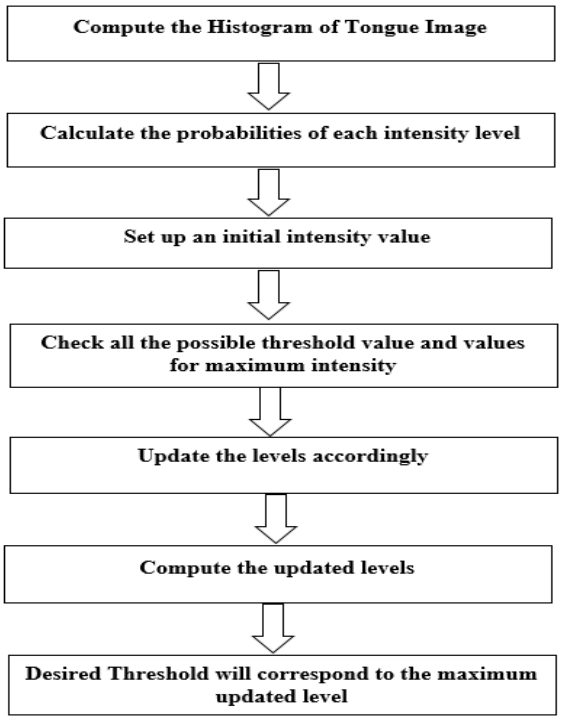


Fig 2.3. Flowchart algorithm for Otsu thresholding

2.2.2. Watershed Thresholding

Region-based method for segmentation. This method is based on grayscale morphology. The steps of watershed segmentation are:

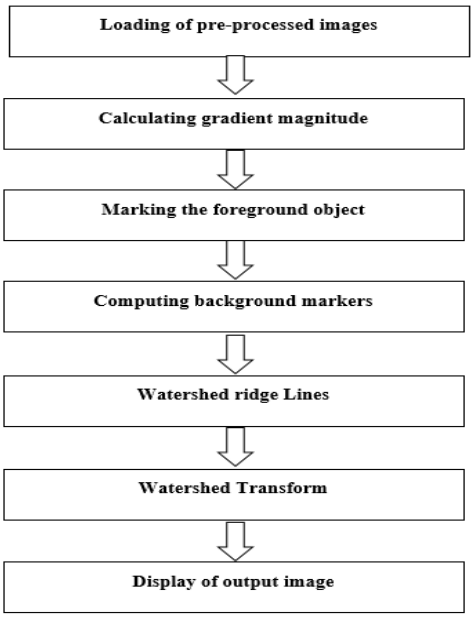


Fig 2.4. Flowchart algorithm for Watershed Segmentation

2.3 Marker and object boundary superimposition by ridgelines

Here, convolution and correlation of the morphological operators are carried out for better tongue image processing. The steps of computation are as follows:

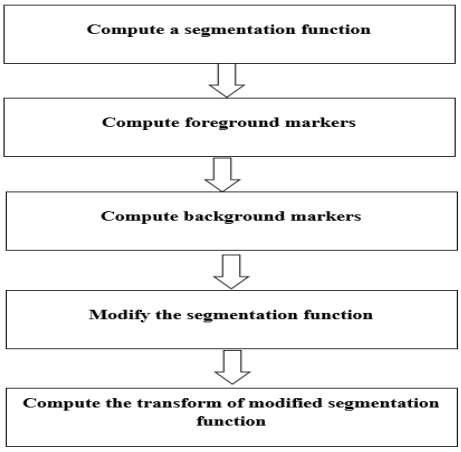


Fig 2.5. Flowchart algorithm for Marker and object boundary superimposition by ridgelines

3. Results

Step 1: Pre-processing of Image

The input image is preprocessed to acquire the target region from the geometry of the tongue. Image re-sizing, color conversion, region growing, and region segmentation of the image are carried out.

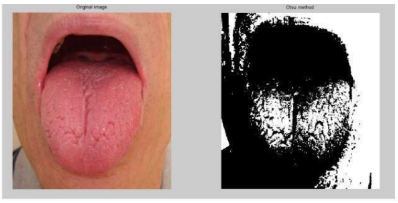


Fig 3.1. Output after pre-processing of the tongue image

Step 2: Contouring

The contour region of the tongue image is selected. The two-point contour method is used. The initial point is selected by the computer, and the final point is set by the user after selecting the region. Once the contour region selection is done, for the target region or area of interest, the greyscale level is set at around 255, and is set at 0 for the region not to be considered while doing tongue analysis.

Fig 3.2. The output of contouring of the sample tongue image

Step 3.1: Otsu thresholding

All possible threshold values are jotted down from the histogram plot. The measure of the spread of the pixel value on each side of the threshold is calculated. Finally, the sum of the foreground pixel and the background pixel is selected such that it has a minimum value.

Fig 3.3. The output of Otsu thresholding of the sample tongue image

Step 3.2: Watershed Segmentation

Watershed Segmentation marks the foreground objects and background locations. Based on grayscale morphology, image segmentation based on region processing is carried out.

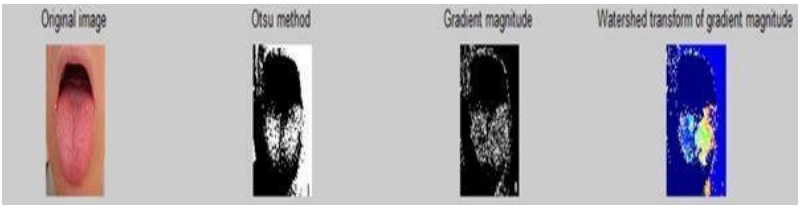
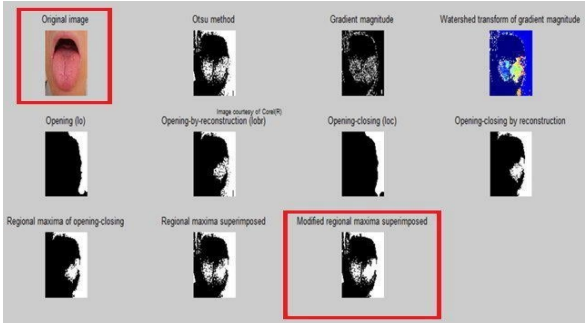


Fig 3.4. The output of watershed segmentation on the sample tongue image

Step 4: Watershed on Otsu thresholding output

For every pixel value threshold and the associated region is determined. its pixel in the scaled image is measured. The pixel value for this later scaled image is also Computation of all the steps.



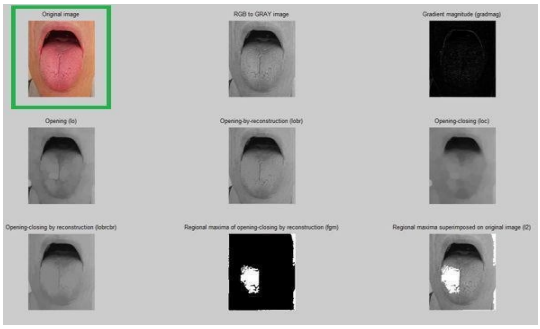


Fig 3.5. The output of Watershed on the Otsu thresholding result set

Step 5. Marker and object boundary superimposition by ridgelines

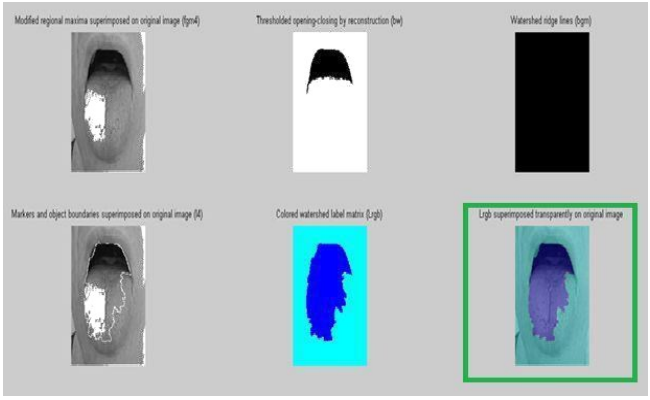


Fig 3.6 Output after computing all steps by ridgelines

4. Analysis of various disease

i. Psoriasis (Diabetes)

The tongue shows red patches with yellow or white borders. Swelling and redness on the tongue are also seen. Fissures or cracks on the surface of the tongue are observed. Upon running the segmentation method on the sample images, the region with the high level of coating can be easily identified. Based on the regional mapping in MATLAB, we can identify the disease as Psoriasis.

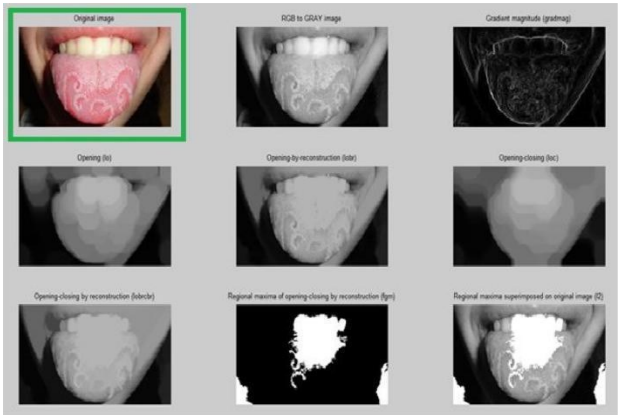


Fig 3.7.1. The output of Psoriasis (Diabetes) diagnosed tongue

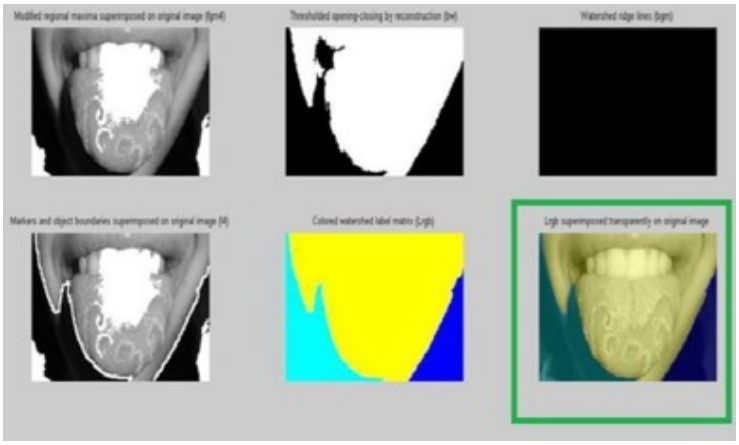


Fig 3.7.2. The output of Psoriasis (Diabetes) diagnosed tongue

i. Adrenal Gland Problems

Bluish purplish tongue, scalloped edges are observed. The purple tongue could indicate a problem with your health, from a vitamin deficiency to an adrenal gland problem. For adrenal gland-related problems, the tongue region mapping where the shade is darker is highlighted on the superimposed image and is a clear indication of the problem.

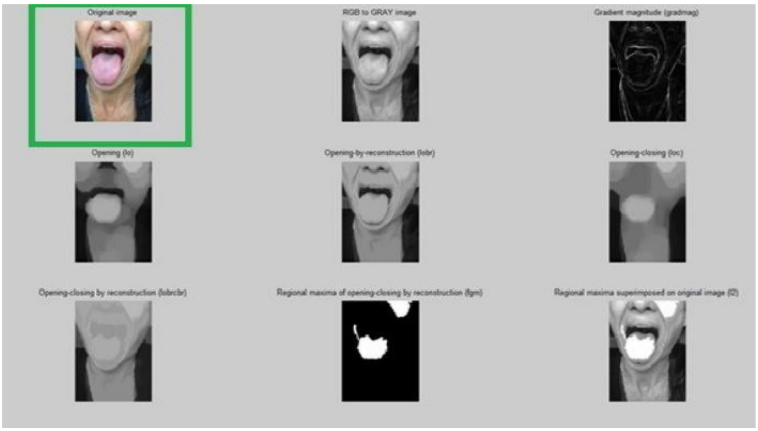


Fig 3.8. Output of the tongue diagnosed with an adrenal gland-related problem

5. Distinguishing tongue image data based on energy values:

Any image is an array of pixels. The energy of an image corresponds to the localized pixel intensity change. Energy is defined based on a normalized histogram of the image. Energy values are an indication of the grey level distribution. Gray levels are inversely proportional to Energy value; when the number of grey levels is low then energy is high and when the number of gray levels is high energy is low.
We calculated the energy values of various tongue images using a code in MATLAB. After sampling the images, we analyzed the result sets and did an average on them to conclude the energy values. The energy values of normal healthy tongue and other disease diagnosed tongues have been listed below.

i. Energy values of various tongue samples:

Table 1. Energy values range of various tongue image samples run through MATLAB

Sr No.	Tongue condition	Energy Value
1	Normal healthy tongue	(1-9) *10^12
2	Kawasaki disease Tongue	(1-9) *10^16
3	Diabetic (Psoriasis) Tongue	(1-9) *10^13
4	Diabetic (Thrush) Tongue	(1-9) *10^14
5	Adrenal's diseased Tongue	(1-9) *10^09
6	Goiter Tongue	(1-9) *10^07

The energy values noted for normal healthy tongues on average are in the range of ((1-9) *10^12)
While it was noted that the energy values for the tongues of people suffering from various diseases are either below or above that range as mentioned in table 1 above.
Thus, based on the energy values of the sampled image, we can estimate some of the disease types.

6. Conclusions

Image segmentation, feature extraction, and the Watershed on Otsu thresholding algorithm help us classify the processed images and classify the diseases based on different parameters.

This computerized method using the MATLAB program will help us do disease classification by characterizing differences in tongue features. Prognosis of various diseases by analyzing the tongue condition will be possible. Real-time tongue diagnosis imaging could be carried out in the near future.

As seen in the computation histograms, the processing time of Otsu thresholding is faster as compared to watershed segmentation. Also, the probabilities of each intensity level and the maximum intensity value computation were much faster in MATLAB for Otsu thresholding. During the computation run, it was observed the intensity of images with greater complexity and processing time is easier with the Watershed segmentation method. Watershed segmentation is simple to carry out. However, it has the disadvantage of over-segmentation and poor processing of thin structures.

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