An Approach for Tongue Diagnosing with Sequential Image Processing Method

M. Dhanalakshmi, P. Premchand, and A. Govardhan

***Abstract*—Tongue diagnosis is one of the important area in diagnosing most of the diseases, thus tongue diagnosing has received more significance among the experts. Tongue diagnosing is usually carried out by processing the tongue images, but the processing of tongue image is not easy task to carry out. The difficulty strikes because of the irregular shape of the tongue, interference of lip with the tongue, the different shape of the tong etc. In this paper, we proposed a sequential method for processing the tongue image. The method consists of mainly three phases, first, shape detection phase, an edge detector with the aid of region growing algorithm is used for extracting the shape of the tongue. Second, color extraction, pimple detection and crack detection are done with help of color intensity extraction method. Finally, the texture extraction of the tongue is done using the LGXP method, which is efficient in finding texture from an image. The aim of our method is to reduce the complexity in tongue segmentation. The experimental results revealed that our methods produced significant result for the tongue image segmentation. the result produced showed that, the boundary detection , texture of the tongue and shape are done correctly.**

***Index Terms*—Tongue segmentation, image processing, edge detector, region growing, color intensity, LGXP.**

I. Introduction

Medical images are crucial parts for recognizing and examining different body structures and the diseases upsetting them. The task cited above requires accurate examination and processing of the medical image. Tongue image processing needs some special attention in the field of image processing and disease analysis, because of the irregular shape, color, texture, etc. of the tongue. However, one significant dilemma in tongue diagnosis is that, its practice is subjective, qualitative and complicated in automated diagnosis [1]. The tongue characteristics are mainly concentrated in its edges, so the size and shape of the tongue should be given an important attention for processing the image. Hence, for the analysis of tongue image, we have to examine the shape feature, color feature and texture feature of the tongue image separately. The shape extraction is for identifying the characteristics of different shaped tongues, and color identification is for identifying different diseases affecting the human body. Texture identification provides a clear processing of the tongue image. A number of algorithms have been proposed for the processing of tongue images.

The processing of tongue image navigates through different steps like, segmentation of tongue area, identifying the color and texture of the tongue, highlighting the irregularities and disease affected parts etc.

At present, there are two major concerns in automated tongue analysis [2]. The first is the objective illustration of tongue's color, texture and coating with the support of image analysis technology [1], [3]-[6]. Second one is the automatic segmentation of tongue [1], [7], [8]. Rather than these two issues, the conventional tongue diagnosis has its unavoidable restrictions. The clinical capability of tongue diagnosis is determined by the know-how and knowledge of the physicians and the ecological factors such as variations in light sources and their brightness have immense authority on the physicians in obtaining good diagnostic results from the tongue. Finally, conventional tongue diagnosis is intimately linked to the detection of syndromes, and it is not splendidly understood by Western medicine and modern biomedicine [2]. Tongue segmentation is one of the most prerequisite steps in automated tongue diagnosis system and is very hard due to the complexity of pathological tongue, variance of tongue shape and infringement of the lips [1]. Thus, a number of researches have been carried out for to find an effective remedy for the problem associated with the tongue segmentation.

The processing of tongue image is a complex task, because of the unavailability of specific processing methods. A number of methods have been developed to efficiently process the tongue image. Since the need of an accurate and well equipped tongue processing method comes more frequently. Several methods have been proposed for the analysis of tongue image segmentation and every methods performed good by its own algorithms and functions. Though researchers have made significant advancement in the standardization and quantification of tongue diagnosis, there are still significant problems with the existing approaches. First, some methods are only concerned with the detection of syndromes in tongue consequently; they will not be extensively accepted, especially in Western medicine. Second, the original validity of these methods and systems is usually derived from a comparison between the diagnostic results that are acquired from the methods or systems and the judgments made by skillful practitioners of tongue diagnosis. That is, they cannot hope to keep away from subjectivity, using such an approach. Third, only very few samples are used in the experiments and this is far from meeting the requirements of obtaining a reasonable result in statistical

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pattern recognition. Last, many of the developed systems are only devoted to the identification of pathological features (such as the color of the tongue and the furring of the tongue) in tongue [2].

Earlier approach such as gradient operator method isapplied to detect the boundary of the tongue. Another approach is an edge detector with contour model to crop the tongue area [1], [7], [8]. The irregular shape of the tongue badly affects the gradient on parts of the boundary that result in bad segmentation result. Therefore, it is required to put up an objective and quantitative diagnostic standard for tongue diagnosis. So, for an effective diagnostic standard for tongue diagnosis, we proposed a new method, which is a gradual, step by step diagnosis of the tongue image. The system consists of four steps mainly; initially we extract the shape of the tongue image using edge detection algorithm and region growing algorithm. Secondly, we extract the pimples and cracks of the tongue with help of intensity measures. We use the same color intensity method in the third phase for the extraction of the color feature of the tongue. Finally, we extract the texture of the color using the LGXP method [9] which an effective mechanism for texture extraction from images. Since our proposed method is sequential process, result entirely depends on the input and output of different spaces. We uses the output of one phase as the input of the other phases, by this technique we improves the effectiveness of the tongue diagnosis. The evaluation of the result showed that our proposed method provided expected results in diagnosing the tongue image.

The rest of the paper is organized as follows. A concise review of the researches related to the proposed approach is given in Section II. The background information about the tongue image is given in section III. The proposed approach for tongue image segmentation is illustrated in Section IV. The results obtained on experimentation of the proposed approach are provided in Section V. Finally, the conclusions are summed up in Section VI.

II. Review of Related Works

Recently, developing approaches for segmenting the tongue images have received a great deal of attention among researchers. A brief review of some recent researches is presented here.

Wangmeng Zuo et al. [1] have presented a technique for automated tongue segmentation by merging polar edge detector and active contour model. First a polar edge detector is proposed to efficiently excerpt the edge of the tongue body. They announced a technique to filter out the edge that is of no use for tongue segmentation. A local adaptive edge bi-threshold technique is also projected. Finally an initialization and active contour model are suggested to segment the tongue body from the image. Experimental results revealed that the tongue segmentation can segment the tongue precisely. A measurable assessment on 50 images shows that the mean DCP (the distance to the closest point) of the proposed technique is 5.86 pixels, and the average true positive (TP) percent is 97.2%.

Bo Pang et al. [2] have presented a tongue-computing model (TCoM) for the diagnosis of appendicitis based on quantitative measurements that comprise chromatic and textural metrics. These metrics were calculated from true color tongue images by means of suitable procedures of image processing. They suggested the technique to address the problems such as, the clinical applications of tongue diagnosis have been restricted due to two factors: (1) tonguediagnosis is typically centered on the capacity of the eye for detailed discrimination; (2) the accuracy of tongue diagnosis is governed by the experience of physicians; and (3) customary tongue diagnosis is always dedicated to the identification of syndromes other than ailments. Applying their method to clinical tongue images, the tentative results are promising.

Yue Jiao et al. [10] proposed a tongue classification method centered on SVM. The classifiers typically have poor performance. In contrast, Universum SVM is a favorable technique which includes a priori information into the learning process with labeled data and irrelevant data (also called Universum data). In tongue image classification, the number of immaterial occurrences could be very large as there are many unrelated categories for a particular tongue's type. But not all the irrelevant occurrences combined in training can enhance the classifier's performance. So an algorithm of choosing the Universum samples is also presented in this paper. Experimental results revealed that the Universum SVM classifier is better and the algorithm of choosing Universum samples is effective.

Yang Ben Sheng et al. [11] proposed an image segmentation algorithm centered on the shortest path. The algorithm is superior to the conventional region growing algorithm (RGA), it lacking of certain disadvantages experienced by old-fashioned region growing built on competing seeds. This technique was enlightened by the water free movement in surface of terrain. In their method, each pixel node will be allocated to an optimal path, in order to ensure integrity and continuity of segmentation objects, they added leaking detection into the algorithm. The results of running both the proposed and the traditional algorithm on medical tongue images and other images demonstrate the dominance of the proposed algorithm based on the shortest path. The proposed algorithm depicts the contours of the object area precisely, particularly when it is used to segment the local object of the image, the segmentation outcomes is useful to sequence image analysis and patter recognition.

Wang X and Zhang D [12] proposed an optimized correction scheme that amends the tongue images captured in various device-dependent color spaces to the target device-independent color space. The correction algorithm in this system is produced by comparing numerous widely held correction algorithms, i.e., polynomial-based regression, ridge regression, support vector regression, and neural network mapping algorithms. They check the performance of the suggested scheme by calculating the CIE L(*)a(*)b(*) color difference ($\Delta E(ab)(*)$) between estimated values and the target reference values. The tentative results on the color checker revealed that the color difference is less than 5 ($\Delta E(ab)(*) < 5$), while the tentative results on real tongue images illustrate that the distorted tongue images (taken in different device-dependent color spaces) become more steady with each other. In actual fact, the average color difference amid them is significantly abridged by more than 95%.

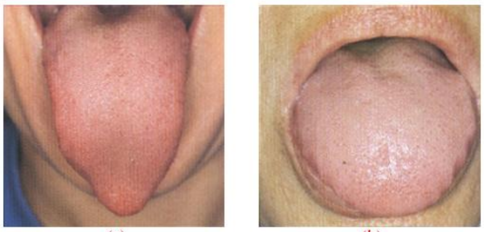
Xiu-Qin Zhong et al. [13] established a technique to segment the tongue image spontaneously with the mouth location method and active appearance model (AAM). With the help of a specific feature of the mouth, they could locate the darkhole's site effortlessly and quickly. For the close relationship concerning the mouth and tongue, they predicted the approximate area of the tongue. Then they used the AAM to segment the tongue from the image completely, which uses texture and shape of an object. During the AAM search, they constrained the initial displacement and size in the approximate area. For those images that could not locate the mouth, they used a multi-initial displacement technique in the AAM search to optimize the result. The experimentation indicated that their technique is accurate and effective.

Wenshu Li et al. [14] have suggested a method for tongue contour extraction based on improved level set curve evolution. They offered an automatic initialization of contour by the feature of tongue in the HSV color space. Improved level set method takes tongue contour shape constraint characterized by energy function among the evolving curve and parametric shape model. In addition to this, the orderliness of the level set function is innately conserved by the level set regularization term to ensure accurate computation. Tentative results for the large database of tongue images reflected desirable performances of the technique.

The segmentation of the body of tongue plays a significant part in automatic tongue diagnosis in Traditional Chinese Medicine. If there are comparable grayscales near the boundaries of the body of tongue, it is tough to excerpt the body of tongue suitably with some standard methods directly. In order to overcome this effort, Wenshu Li et al. [15] have offered a technique that joins prior knowledge with improved level set method. First, the contour of tongue is initialized in the HSV color space and a technique which improves the contrast between tongue and other parts of the tongue image is presented. Then, a region-based signed pressure force function is suggested, which can proficiently stop the contour at weak edges. To finish with, a Gaussian filtering process was used to further regularize the level set function as an alternative of reinitializing signed distance function. Experiments by abundant real tongue images showed desirable performances of our method.

III. Tongue Image Analysis

Tongue images are the elementary features for diagnosis various diseases. For the ease of the diagnosis, the tongue images should be processed clearly and properly. As we discussed earlier, tongue image processing is quite a tough task due to the tongues particular features like, its irregular shape, interference with the lip etc. So it's difficult to get an effective diagnosis of diseases without an effective tongue image processing methods. The main features that are used for diagnosing the tongue include shape, color, pimples, cracks and texture of the tongue.



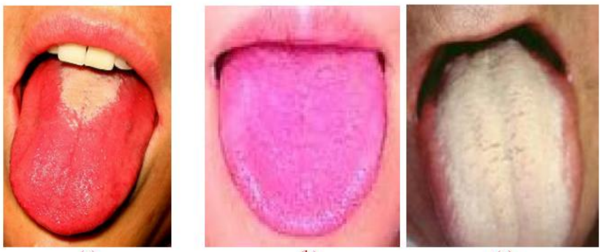
(a) (b)

Fig. 1. Two tongue images with different characteristics.

The Fig. 1 shows images of the tongues that shows different shapes and characteristics. When we consider a tongue, we should be aware about the diagnosing factors of the tongue. The shape, size, color, etc. every feature describes special features of the tongue. Normal healthy tongue image is represented in the Fig. 2.

Fig. 2. Normal healthy tongue image.

The symptoms of any of the body problem such as heart associated problems, kidney related problems, etc. will be reflected as abnormalities in any of the features. So, most of the diseases can be detected easily by the examination of the tongue. For detatiled analysis of the tongue, we use the tongue images, with the help of the clear tongue images a detailed diagonosis of tongue can be possible. Now, let us consider some tongue images and the disease analysis.The main features that we consider for tongue diagonosis are shape, color and tongue body cracks and pimples.



(a) (b) (c)

Fig. 3. Tongue image with different colors.

Here, the Fig. 3 shows the tongue images with different colors. Diseases caused by the virus and bacteria result in the difference in color. Thus tongue can be characterized with different measures. The common measures of the tongue can be detailed as follows.

Width: A wide tongue on the whole shows a composed physical and mental character. A lack of physical flexibility with noticeable strengths and weaknesses is depicted by a narrow tongue. They may be sharp thinkers but generally have a narrow view. A generally loose and expanded physical condition and a tendency to have more psychological concerns are related to a wide tongue.

Tip: A flexible yet firm physical and mental condition is mirrored by a rounded tip. A pointed tip reveals a tight, perhaps even rigid physical condition and an antagonistic or even unpleasant mentality. A very wide tip shows an overall weakness of the physical body and a limp or even "spaced out" mental situation. A tendency toward physical and mental imbalances with the likelihood of sharp variations in thinking and mood is mirrored by a divided tip.

Thickness: A flat tongue echoes a composed condition and the competence to docilely adapt to situations. A calmer and easy going trend is depicted by a thin tongue. It also reflects a more mental orientation. A more bodily orientation is reflected by a thick tongue, they tends to be self-confident or even forceful.

Color: Inflammation lesions or ulceration and sometimes a deterioration of the associated body part are pointed out by dark red. White designates stagnation of blood; fat and mucus deposits or feebleness in the blood leading to such disorders as anemia. A disorder of the liver and gallbladder is specified by yellow. This results in a surplus secretion of bile, deposits of animal fats, particularly in the middle organs of the body, and likely inflammation. Blue or purple shows the stagnation of blood circulation and a grave fading of the part of the digestive system that is connected to the zone of the tongue. Internal conditions can be understood by analyzing the color on the underneath of the tongue. As a summary, the colors and their symptoms given above are the same, with the subsequent exceptions. Surplus of blue or Green shows maladies in the blood vessels and in blood quality and circulation. Surplus purple color mirrors ailments of the lymphatic and circulatory system. It designates a fading of the immune capacity of the blood vessels.

Texture: The texture of the tongue mainly consists of two states; a swollen or enlarged tongue indicates full state. A shriveled or withered looking tongue indicates an empty state.

IV. An Effective Approach to Tongue Image Segmentation

We introduced a new method for the processing the image of the tongue. We have introduced a sequential approach for the tongue analysis. The sequential process consists of extraction of the shape feature, color feature and so on. We have developed a systematic approach for the efficient processing of the tongue image. The illustrated block diagram in Fig. 4 represents the step by step process we have undergone in our proposed method.

A. Shape Extraction

As we discussed earlier, shape extraction of tongue is a hard process in the tongue image processing. We have developed a new approach with aid of the region growing algorithm. We have the tongue image as the input. In order to obtain the shape of the tongue, we implement an edge detector to the input image. The edge detector works under the canny edge detection algorithm [16]. After applying the canny edge detection algorithm, we got a segmented image of the tongue. The segmented image is then subjected to noise removal processes. In this process, the unwanted image parts are removed and we will get a clear image of the segmented tongue. Since the tongue is in irregular shape, the edges will not be a connected one, so with help of the region growing method we can overcome this problem.

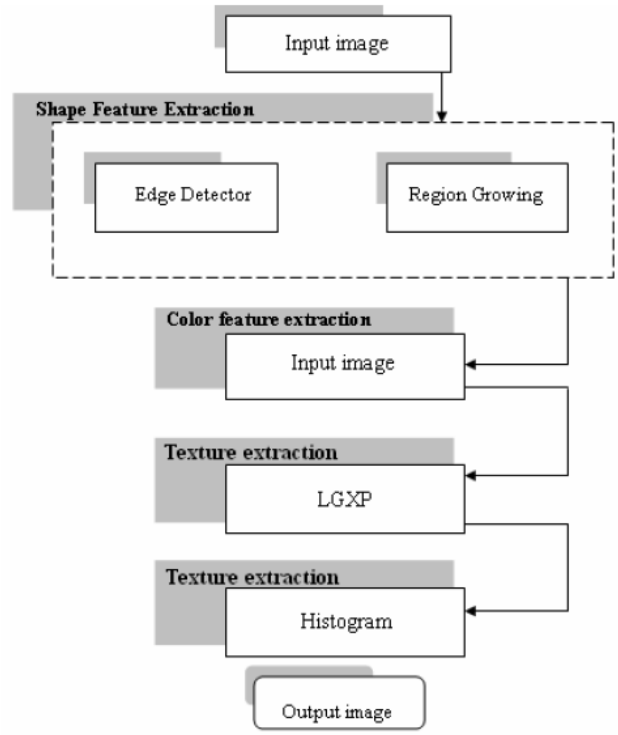


Fig. 4. Block diagram of the proposed approach.

Region growing [17] is executed by considering a seed and by selecting its similar seeds. The seed can be selected by plotting the histogram of gray level values of the image and extracting the peek values. Then neighboring seeds are considered and those neighbors which are similar to the seed are selected and this process continues till no other neighbors are selected. The application of region growing method in our method can be illustrated by the following Fig. 5.

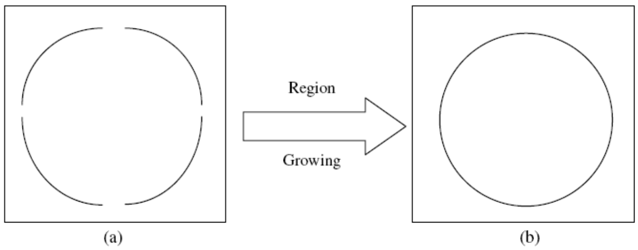


Fig. 5. (a) Image after the canny edge detection, (b) Image after region growing algorithm.

In the above Fig. 4.a, we see the image after the canny edge detection process, Fig. 4.b illustrates the image after region growing algorithm. It is evident that after the region growing the image becomes more clear and regular one, with help of these we can easily identify the shape of the tongue.

B. Pimple Detection in Tongue Image

For the detection of pimples in the tongue, we use the same region growing method, but for the pimple detection purpose we use the segmented tongue image. We consider a particular area in the tongue through some arithmetic calculation. After selecting the particular area we assign a threshold for detecting the pimples. So, those values that come below the threshold value are selected and after the complete process the pimples are highlighted. The Fig 6 illustrates the pimple detection method in tongue image.

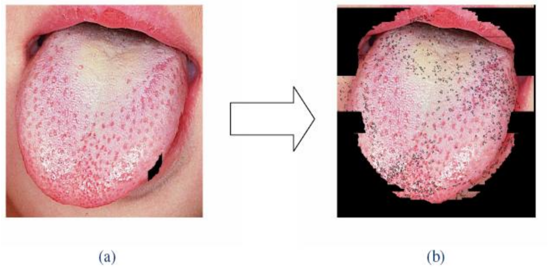


Fig. 6. Pimple detection method.

C. Color Extraction

The color feature is extracted with help of intensity filtering methods. We extract the color of the tongue on the basis of the intensities presented in the different areas of the tongue. We apply this feature because intensity levels will be different for different areas of the tongue. So with help of this intensity method, we can extract the color feature, the pimples like structures in tongue. Initially, we convert the color image in the gray scale image. Then, we find the different intensity in different areas of the tongue through the histogram method. After plotting the histogram, the difference in intensity is identified then a threshold is applied. According to the value of threshold, the areas are selected on accordance with the intensities. The areas with similar intensities are segmented. We identify the white coating, pimples and dominant color of the tongue through this approach. The white coating may dominantly present in dome tongues and in some others it will be less dominant. We select the closely related intensities of all the white coated areas and the selected areas are segmented. The Fig 7 shows the detection of white coating in the tongue. The segmented fig shows the white coated areas in the image.

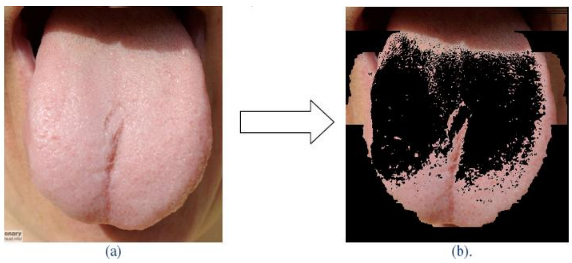


Fig. 7. Detection of white coating.

D. Texture of Tongue Image

The texture of the tongue is extracted using method called Local Gabor XOR Patterns (LGXP) method [9]. This method initially forces the image to undergo a Gabor filtering, where the convolution of the image with the Gabor kernels is done to get the required output. After the Gabor filtering, the filter generates a complex number with real and imaginary parts at every image pixel. With the help of these two parameters magnitude and phase of the image are calculated. But in our method we make use of only the phase information of each pixel and then processing it and plotting histograms in response to the analysis made on each pixel.

In our method, we take a phase range 4 that can be plotted as 0-90, 91-180, 181-270, 271-360 and each of these phases are assigned values 0, 1, 2, 3 respectively. We have opted for four phase range levels because, which achieve a good balance between the robustness to phase variations and representation power of local patterns. After that we do XOR operations on the neighboring pixels. The XOR operation can be defined as

$$A \bigotimes B = \begin{cases} 0, if A = B \\ 1, otherwise \end{cases}$$

We obtain the matrix with the XORed values, after this process we calculate the binary values for each neighboring pixels according to a fixed pixel,

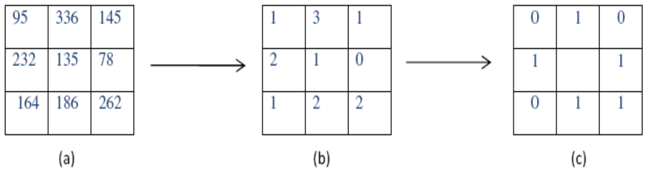


Fig. 8. Example of LGXP method where the phase is quantized into 4 ranges.

In the shown example in Fig. 8, (a) is the matrix showing the initial phase of the pixels after passing through the Gabor filter, (b) is the matrix obtained after the quantization and (c) is the matrix obtained after the XOR comparison with the center quantized value. From the matrix we infer that binary value obtained is 01011101 and its decimal value equivalent value of 93. So following in this manner we obtain a decimal value for each pixel. We plot a histogram with values we obtained through the above mentioned processing. With the pattern defined above, one pattern map is calculated for each Gabor kernel. Then, each pattern map is divided into non-overlapping sub-blocks, and the histograms of all these sub-blocks of all the scales and orientations are concatenated to form the proposed LGXP descriptor.

$$H = \left[H_{\mu_0 v_0, 1}, \dots\dots\dots, H_{\mu_0 v_0, m}, \dots\dots\dots, H_{\mu_0 - 1, v_0 - 1, 1}, \dots\dots\dots, H_{\mu_0 - 1, v_0 - 1, m}\right]$$

where, $H_{\mu,v,i}(i = 1, \dots m)$ denotes the histogram of the i^{th} sub-block of LGXP map with scale μ and orientation v. Thus this histogram plots the texture detail of our tongue image.

V. Results and Discussion

We have implemented our proposed approach using MATLAB (Matlab 7.10) and the results showed that the approach produce better results in tongue segmentation methods. Let us have a detailed look with the different tongue image samples.

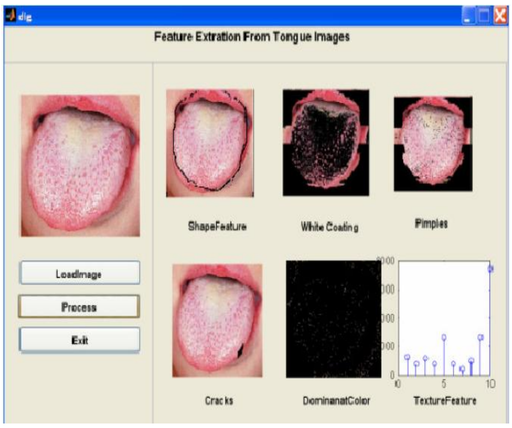


Fig. 9. GUI of the proposed approach with an example tongue image.

The fig 9 shows the GUI (graphical user interface) of our proposed approach. From the fig, we can identify that our methods provide feasible results. When we consider the shape feature of the tongue it is clear that we obtain the correct shape of the tongue. The occurrence of white coating is very low in tongue images, even though our method out performs other methods in the case white coating detection. When we consider the pimples in the tongue, our method performs better with the help of the region growing algorithm. The intensity method we adopt is providing good result in finding the color feature of the tongue. The dominant color also can be easily identified with the help of our method. The above figure shows the significance of the dominant color detection and color feature extraction using our proposed approach. The LGXP method is highly efficient in detecting the texture of the tongue. From our experimental analysis it is shown that our proposed method detects almost 80% of the cracks in the tongue. Thus from the qualitative evaluation our methods provides satisfactory results. We have experimented method on different types of tongue images. The results provided satisfactory outcomes. Let us consider some more examples.

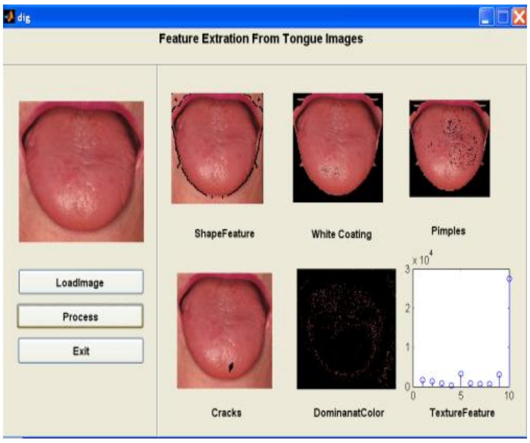


Fig. 10. GUI of the proposed approach with different tongue images.

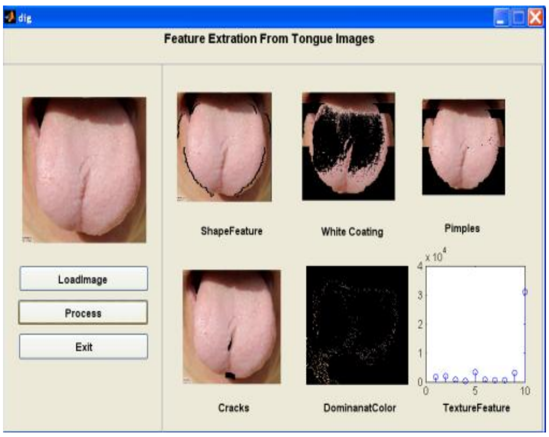


Fig. 11. GUI of the proposed approach with different tongue images.

In the above result, we can see the tongue image is little more regular than the former one. From this example we can identify that the regularity of the edges of the tongue is highly associated to the shape feature extraction. The more regular the edge, the more accurate the result will be. The color extraction algorithm performs in a high range in this case. In the above figs 10 and 11, the detection of crack is done with help of the region growing method. The region growing algorithm connects all the cracked area and provides an expected result. The color dominancy is shown with high precision with help of the intensity extraction method. The intensity of tongue tissue can be easily differentiated from the other that is the reason behind intensity method in our proposed method. But when we consider the other tongue extraction methods, it was found that their color extraction was disturbed with the lip color. In our method we have assigned parameter values to effectively extract the tongue color, which was not affected by any disturbances from the color of the lip. In this example also, the LGXP method performs well and gives the histogram of according to the texture variations.

VI. Conclusion

The tongue image segmentation is key research in the field of tongue image processing and hence there are different methods introduced for the effective processing of tongue images. But with the one or more disadvantages in the processing, new techniques are become necessary. Thus, in our method we have introduces a structural method in which every process is occurring in a step by step manner. In our proposed method, we have provided methods to detect the shape, color, cracks, pimples and texture of the tongue. From the evaluation of the results it is showed that every method we proposed gives the appropriate result and it adds that the proposed approach is well suited for the tongue image processing. Further enhancement to the system can be done by improving the localized intensity methods and edge detection algorithms.

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