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By Using Tongue Detection of Diabetes Mellitus

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Abstract — This paper proposes a non-invasive method to detect diabetic mellitus and non-proliferative diabetic retinopathy with the three groups of features extracted from tongue images which are initial stage of DR based. They are in the form of color, texture and geometry. One of the 21st century's major health problems is diabetic mellitus (DM) & its complication towards retinopathy. Initially, the non-invasive capture device with image correction captures the images of tongue. A tongue color feature gives 12 tongue color gamut, for characterize the 9 tongue texture features the texture values of 8 blocks strategically located on the tongue surface. On the basis of measurements, distance, areas & their ratios 13 features extracted from tongue images to represent geometry features. The proposed method can separate Healthy/DM tongues & NPDR/DM- sans NPDR (DM samples without NPDR) tongues using features with average accuracies of 80.52% & 80.33% respectively of 34 features. From database 29 samples in DM are NPDR from sample consisting 130 Healthy and 296 DM samples.

Keywords — **Matlab, Image Pre-processing, Tongue color features, Tongue texture features, Tongue geometry features, Diabetes Mellitus detection, Non-proliferative Diabetic Retinopathy features**

I. INTRODUCTION

In the observation of World Health Organization in the year 2000 that there is 171 million people in the world are having the diabetes mellitus(DM) and it may be get increased up to 366 million in 2030, though it may lead to cause of death, disabilities, & economic hardship in the world because of this disease. Two main types of DM exist, people which are fails to produce insulin and they require injection of it are type 1 DM & people can be categorized by insulin resistance are the type 2 DM which are most common type. Managing by eating well, exercising, and maintaining a healthy lifestyle type 2 DM can be controlled. In the medical professionals to diagnose DM, the Fasting plasma glucose (FPG) test is the standard method. FPG test is performed after the patient has gone at least 12 h without food, and requires taking a sample of the patient's blood (by piercing their finger) in order to analyze its blood glucose levels. Even though this method is accurate, it can be considered invasive, and slightly painful (piercing process). Diabetic retinopathy is a well-recognized complication of diabetes mellitus. Well-conducted clinical trials have shown that good control of diabetes and hypertension significantly reduces the risk for diabetic retinopathy, and there is evidence from studies spanning more than 30 years that treatment of established retinopathy can reduce the risk for visual loss by more than 90%.[1][2]

Care for diabetic retinopathy is relatively expensive and requires properly trained eye-care professionals. The decisions made by each country are adapted to their resources, social expectations and available health-care infrastructure. Effective services for prevention and treatment of diabetic retinopathy can be provided only if adequate medical services for patients with diabetes mellitus are in place.

WHO estimated that, Diabetic retinopathy (DR) is a micro vascular complication of DM that is responsible for 4.8% of the 37 million cases of blindness in the world. Disease if detected can be treated to prevent further progression and sight loss is in earliest stage is known as non-proliferative diabetic retinopathy (NPDR). Various imaging modalities such as redfree, angiography, and color fundus imaging are used to examine the human retina in order to detect DR and subsequently NPDR.[2]

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II. RELATED WORK

Detecting DM images to obtain diabetic levels. Figure below shows the block diagram for detecting diabetes level using DM input images.

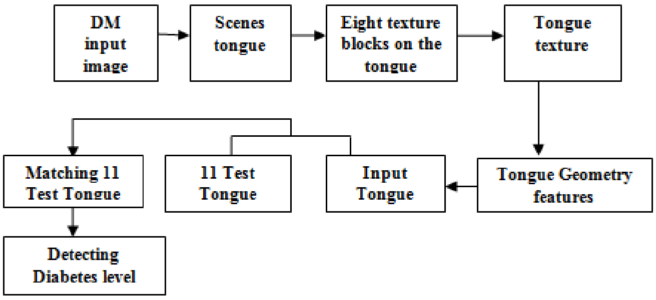

Figure 1: block diagram for proposed work

A. Tongue Image Preprocessing

The image is captured when patient place e their chin on a chinrest while showing their tongue to the camera from ranges 257*189 pixels to 443*355 pixels the images captured in JPEG format. By the changes of illumination & device dependency that pixels color were corrected to eliminate any variability in color images.

Automatic segmentation is applied to each image in order to separate its foreground pixels from its background when the tongue images are captured. By first minimizing the energy function of BEDT (bi-elliptical deformable template) followed by the energy function of BEDC (bi-elliptical deformable counter). BEDT captures the overall tongue shape features & BEDC deform to match the local details. For three groups of features, color, texture & geometry to be extracted from a tongue foreground image in the preceding steps which gives a final result is a binary tongue image which defines foreground pixels (tongue surface area & its edge) from its background pixels (area outside the tongue edges).

B. Tongue Color Features

The color feature which forms with every foreground tongue pixel is compared to 12 colors which represents the tongue color gamut & assigned its nearest color.

Figure 2. Represents chromaticity diagram where all possible colors are in the visible spectrum from further observation gives that 98% of the tongue pixels lie inside the boundary 12 colors plotted were selected with the help of the RGB color space to represent better tongue color gamut.

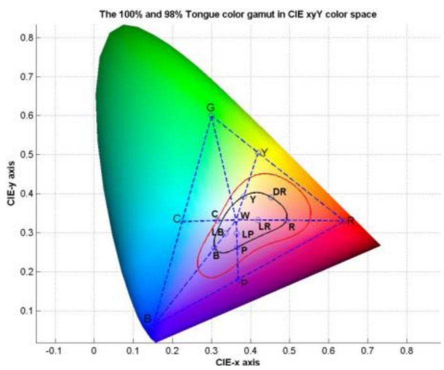

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Figure 2: By using several points drawing lines from the RGB color space represents the tongue color gamut.

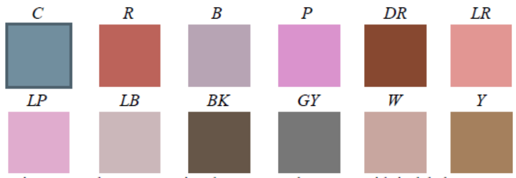

Figure 3: the tongue gamut represented in colors with its label on top

The color squares with its label on top which are representing the tongue color gamut are extracted from figure 2.The obtained values are compared to 12 colors from the tongue color gamut and assigned the color which is closest to it. After evaluating all tongue foreground pixels the total of each color is summed and divided by the total number of pixels. DR, LR, and Y are greater in healthy samples in DM and GY is higher in NPDR and remaining mean color features are similar

C. Tongue Texture Features

Texture Extraction of tongue image is done in tongue texture features. The image of 8 Blocks of size 64*64 strategically located on the tongue surface are taken. The intention for 8 blocks of 64*64 is that it covers all 8 surface areas with minimum overlap perfectly. The Blocks are calculated by first locating the center of the tongue using a segmented binary tongue foreground images. The edge of the tongue are established & equal parts are measured from its center to position the 8 Blocks as shown in figure 4.

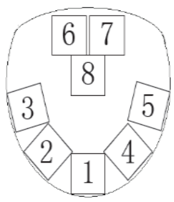

Figure 4:Location represents 8 texture blocks on the tongue

The edges of the tongue are established and equal parts are measured from its center to position the 8 blocks. Block 1 is located at the tip. Block 2 and 3, and Blocks 4 and 5 are on either side, Blocks 6 and 7 are at the root, and Block 8 is at the center. For representation of texture, the Gabor filter is used in image processing which is a linear filter. Healthy samples contain higher texture value in Block 7 and NPDR texture values are higher for the remaining Blocks.

D. Tongue Geometry Features

In tongue images there are 13 geometry features extracted. These features are based on measurements, distances, areas, and their ratios.

Width : width is measured as the horizontal distance along the x axis from tongues furthest right edge point to its furthest left edge point

$$w = x_{max} - x_{min}$$

Length : length is measured as the vertical distance along the y axis from a tongue furthest bottom edge point to its furthest top edge point

$$l = y_{max} - y_{min}$$

Length-Width Ratio : it is the ratio of tongues length to its width

$$lw = l/w$$

Smaller-Half Ratio : it is the half distance of l or w depending on which segment is shorter

$$z = min(l, w)/2$$

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Center Distance : it is the distance from widths y axis center point to the center point of l

$$cd = \frac{\left(max\left(y_{x_{max}}\right) + max\left(y_{x_{min}}\right)\right)}{2} - y_{cp}$$

where $y_{cp} = (y_{max} + y_{min})/2$.

Center Distance Ratio : it is the ratio of cd to l

$$cdr = \frac{cd}{l}$$

Area : The area (a) of a tongue is defined as the number of tongue foreground pixels.

Circle Area : Circle area (ca) is the area of a circle within the tongue foreground using smaller-half-distance z

Circle Area Ratio : it is ratio of ca to a

$$car = \frac{ca}{a}$$

Square Area : Square area (sa) is the area of a square defined within the tongue foreground using smaller-half- distance z

Square Area Ratio : it is the ratio of sa to a

$$sar = \frac{sa}{a}$$

Triangle Area : Triangle area (ta) is the area of a triangle defined within the tongue foreground

Triangle Area Ratio : it is the ratio of ta to a

$$tar = \frac{ta}{a}$$

III. RESULT

The numerical results were obtained on tongue images from the blood test & other examinations the healthy samples were verified. If indicators from these tests fall within a certain range they were deemed healthy. FPG test was used to diagnose diabetes in the DM. with the average of all 5 repetitions recorded as the final classification rate. To measure the performance average accuracy was employed as

$$Average\ Accuracy = \frac{sensitivity + specificity}{2}$$

By using geometry features ta, the highest average accuracy was 66.26%. Sequential forward selection(SFS) is a feature selection method that begins with an empty set of features. It adds additional features based on maximizing some criterion & terminates when all features have been added. by examining the best combination from all features (SFS), the highest average accuracy of 80.52% can be accomplished (via SVM), with a sensitivity of 90.77% and a specificity of 70.27%. ROC analysis was performed on this classification, then the red ROC curve in figure 5.

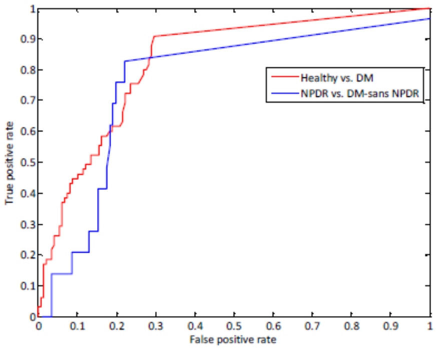

Figure 5: ROC curves for healthy vs DM and NPDR vs DM-san NPDR

The average accuracy of this result is higher than the optimal combination from the three feature groups (77.39%), and contains fewer features. At the same time, it significantly improves upon the use of all features without feature selection, which obtained an average accuracy of 58.06% (*k*-NN) and 44.68% (SVM).

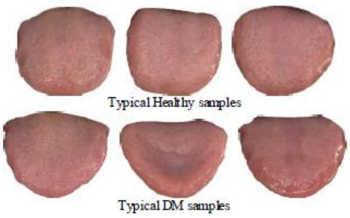

Figure 6: typical healthy and DM samples

IV. CONCLUSION

From the three groups of color, texture & geometry a non-invasive approach to classify Healthy/DM & NPDR/DM-sans NPDR samples was extracted from tongue images was proposed. 12 color representing tongue image was first applied to tongue color gamut. Then the texture value is calculated by 8 blocks strategically located on the tongue were extracted. On the basis of measurements, distances, areas & their ratios were extracted and got 13 geometry features from tongue images. 130 healthy and 296 DM tongue images were carried by Numerical experiment. The highest average accuracy achieved was only 66.26% by applying to separate Healthy/DM to each feature individually. To produce optimal result obtaining an average accuracy of 80.52%, employing SFS with SVM 9 features were shown. The best result of 80.33% was attained using 5 features, 3 from color & one from texture geometry for NPDR/DM sans NPDR classification. This lays a work for a new way to detect DM for providing a means to detect NPDR without retinal imaging or analysis.

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