International Journal of Pure and Applied Mathematics
Volume 117 No. 15 2017, 1015-1019
ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version)
url: http://www.ijpam.eu
Special Issue

ijpam.eu

Analysis of Diabetes Mellitus and NPDR through Characterization of Changes in Tongue Geometry Features using NN Classifier

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Abstract— **Diabetes Mellitus (DM) and its after effects leading to Diabetic Retinopathy (DR) are the major problems of the current generation. These problems are diagnosed through the way of invasive methods. The invasive methods include blood tests, imaging methods to diagnose the above aforementioned problems. Hence a non invasive method is proposed to detect the DM and NPDR (Non Proliferative Diabetic Retinopathy). The tongue images have been obtained from a group of 10 healthy, diabetic and persons with NPDR through a non invasive image capture device. The captured images are preprocessed for noise removal, color correction and segmentation purpose. Then 13 geometrical features have been measured for all the segmented tongue images. The results are also trained and classified using Neural Network (NN) classifier. From the thirteen obtained features, this proposed method helps in separating or determining whether the person is healthy or diabetic or in the stage of NPDR. The observation made was such that, out of 30 persons, 10 persons had diabetes, 9 had diabetic retinopathy, and 10 were healthy. The NN classifier efficiently classified the tongue images with 97.6% efficiency.**

Keywords— ***Diabetes mellitus (DM) detection, Non Proliferative diabetic retinopathy (NPDR), tongue geometry features, NN classifier***

I. INTRODUCTION

Diabetes Mellitus (DM) is caused due to high levels of blood sugar for a long period of time. There are three types of diabetes, type 1, type 2, and gestational diabetes of which first two are more common.

After the 12 hours of Fasting Plasma Glucose (FPG) test is performed in order to identify the blood glucose level using the blood sample of the patient taken from his/her finger which is invasive and painful. DR and NPDR present in human retina are being detected using the imaging techniques Flourescein Angiography and color fundus imaging which are considered to be invasive. In Color Fundus Imaging the human eye is subjected to bright lights whereas In Flourescein Angiography flourescein is injected into the vein of the human eye.

Therefore some non invasive methods have been proposed to detect Diabetes Mellitus and NPDR using tongue and foot image features. The tongue has unique geometrical features which can differ from a healthy person to a diabetic person to a diabetic retinopathy person. These features can be highly helpful in determining whether the person is healthy or diabetic or in the stage of NPDR and these features of the tongue can be obtained by a noninvasive method. Xingzheng Wang et.al [1] proposed an algorithm that corrects the tongue images captured by different cameras. This was done by comparing different correction algorithms.Wentao Xu et.al [2] made one step ahead in computer-aided tongue image analysis by introducing a fully automatic tongue detection and tongue segmentation framework.

A different shape of tongue other than ellipse could indicate presence of Diabetes .Tayo Obafemi-Ajayi et.al [3] proposed a novel set of features which are used to classify the tongue images in to various stages of Diabetes.

Xing zheng Wang et.al [4] proposed a tongue color space in order to extract the features of tongue by analyzing the characteristics of human tongue color. 13 geometrical features of tongue Images were extracted by Bob Zhang et.al [5] based on measurements, distances, areas, and their ratios. Using all these features, the Normal tongues images and NPDR tongue images were classified.

Diabetes Mellitus can also be detected using novel method proposed by Shu Ting et.al [6] This method depends on facial block texture features using the Gabor filter for the detection of Diabetes Mellitus. N.V.Cibin et.al [7] also extracted 32 features. where 4 energy features using wavelet decomposition which are used to discriminate between Healthy/DM tongues and NPDR/DM-sans NPDR.

S. Sujatha, D. Divya [8] used Median filter for preprocessing the tongue image and used PSVM classifier for classification which resulted in better accuracy than the SVM classifier. Shivani A .Aher et.al and Tina Lidia et.al [9,10] implemented a non invasive method to detect DM and NPDR and 13 features were extracted from the tongue images based on the measurement, distance, area and their ratio. The combination of the color, texture and geometry of the tongue is used to analyze the health condition of the patient and categorize them into three categories.

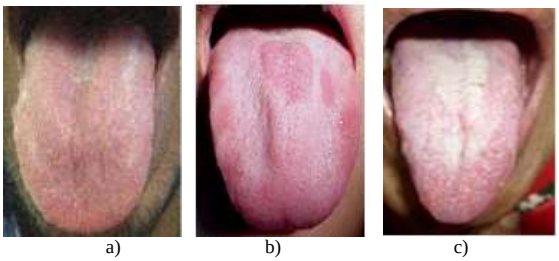
This paper proposes a Noninvasive yet accurate DM and NPDR detection method to detect the DM and NPDR with a

greater accuracy of 96.7%. The captured tongue are preprocessed for noise removal, color correction and segmentation purpose. Then 13 geometrical features have been measured for all the segmented tongue images. The results are also trained and classified using Neural Network (NN) classifier.

II. Materials and Methods

A. Tongue Image Acquisition

The tongue images were taken from 30 persons by using a high end digital camera which has the capability to produce a uniform illumination. A sample of the captured images of healthy, DB and DR affected persons is shown in Fig. 1.



a) b) c)

Fig.1.Captured tongue Images a) healthy b) DM c) DPDR

B. Preprocessing

The camera captures the tongue images with a uniform illumination. The captured images needed preprocessing for obtaining a better output of the captured images. Image preprocessing is the technique of enhancing images and making it ready for further operations. The preprocessing done in our method includes segmentation, noise removal and color correction. The tongue image after noise removal is shown in Fig. 2.

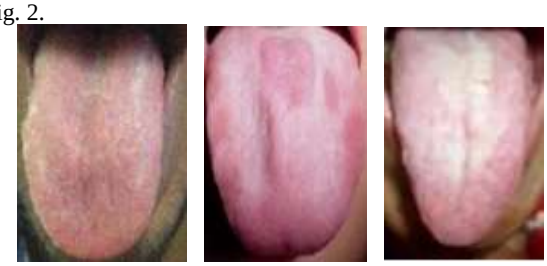


Fig.2.Denoised Images

The captured images are segmented using an automatic segmentation algorithm as the captured images contained the person's mouth, lips, skin surface, etc., Hence, each of the images are segmented for obtaining only the tongue images from its surrounding regions. The image after segmentation is shown in the Fig.3. The collected samples are segmented with a Color Thresholder app using Matlab to mask out only the tongue image.

Fig.3.Segmented Tongue Images

The tongue image contained Gaussian noise which has been removed by using median filter. Color Correction of the healthy and diabetic affected samples is done using Adobe Photoshop. This is done to have a uniform illumination in all the images so that there is no difference in the images.

The images are color contrasted at 45 degree angle curve brightness in Photoshop. That's how the images were made ready for further processing.

III. Tongue Geometry Feature Extraction

13 geometrical features can be extracted from the tongue. They are Length, width, smaller half distance, length-width ratio, area, square area, square area ratio ,circle area, circle area ratio,center distance, center distance ratio, , triangle area and triangle area ratio. The values are calculated and compared for different persons .The values are calculated with a distance tool using MATLAB. The 13 geometrical features and the formulas to calculate the same is given in Table.1.

TABLE 1.Formula to calculate the geometrical parameters

Sl.No	Parameter	Formula to calculate the parameter
1	Width(w)	$w = x_{\max} - x_{\min}$
2	Length(l)	$l = y_{\max} - y_{\min}$
3	Length–Width Ratio(lw)	$lw = l/w$
4	Smaller Half-Distance(z)	$z = \frac{\min(l, w)}{2}$
5	Center Distance(cd)	$cd = \frac{(\max(y_{x_{\max}}) + \max(y_{x_{\min}}))}{2} - y_{cp}$
6	Center Distance Ratio(cdr)	$cdr = cd/l$
7	Area(a)	a= number of tongue foreground pixels
8	Circle Area(ca)	$ca = \pi r^2$ where r = z
9	Circle Area Ratio(car)	$car = ca/a$
10	Square Area(sa)	$sa = 4z^2$
11	Square Area Ratio(sar)	sar=sa/a
12	Triangle Area (ta)	ta= area of a triangle defined within the tongue foreground
13	Triangle Area ratio(tar)	$tar = ta/a$

Where,

$x_{max=}$ the horizontal distance along the x-axis from a tongue's farthest right edge point
x_{min}= the horizontal distance along the x-axis from a tongue's farthest left edge point
$y_{max=}$ the vertical distance along the y-axis from a tongue's farthest bottom edge
$y_{min=}$ the vertical distance along the y-axis from a tongue's farthest top edge point

The geometrical features are graphically represented as shown in Fig. 4, Fig. 5, Fig. 6, Fig. 7 and Fig.8.

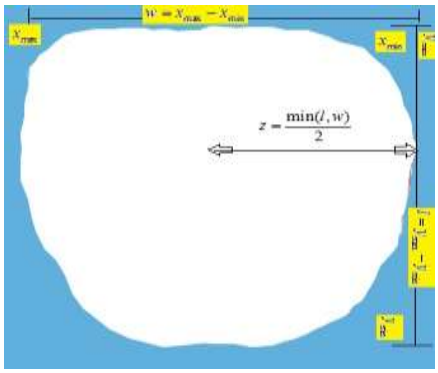


Fig.4.Illustration of features w, l & z

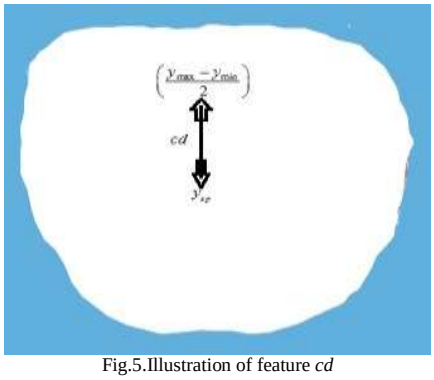


Fig.5.Illustration of feature *cd*

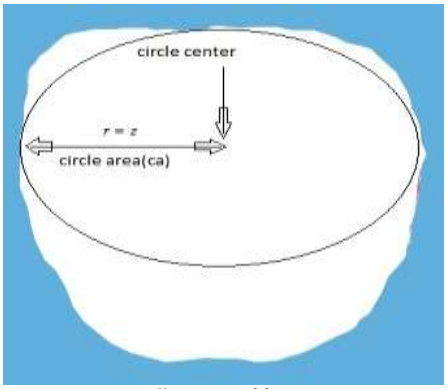


Fig.6. Illustration of feature *car*

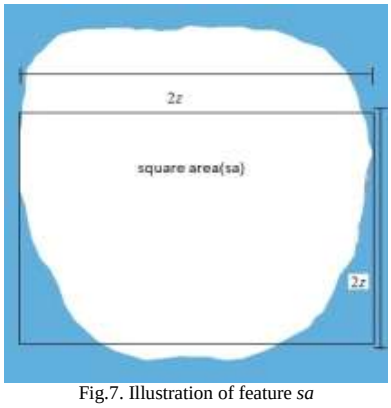


Fig.7. Illustration of feature *sa*

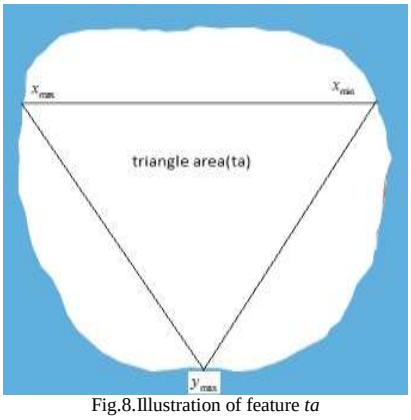


Fig.8.Illustration of feature *ta*

The parameters are calculated and listed for three tongue images in Table. II. In the same way 13 geometrical features were calculated for thirty persons.

TABLE II.ESTIMATED PARAMETERS FOR THREE PATIENTS

S.no	Parameters	Person 1 (healthy)	Person2 (DM)	Person 3 (NPDR)
1	Width	166	220	207
2	Length	291	205	156
3	Length–Width Ratio	1.753012	0.931818	0.753623
4	Smaller Half-Distance	83	110	103.5
5	Center Distance	-145.5	-102.5	-78
6	Center Distance Ratio	-0.66	-0.64	-0.63
7	Area	48306	45100	32292
8	Circle Area	21631	37994	33636
9	Circle Area Ratio	0.447801	0.842439	1.041635
10	Square Area	27556	48400	42849
11	Square Area Ratio	0.570447	1.073171	1.326923
12	Triangle Area	20667	36300	32136
13	Triangle Area ratio	0.427835	0.804878	0.995192

IV. Classification

The features extracted from the tongue images are used for classification. Here, a feed-forward back propagation neural network is effectively used to classify whether the person is healthy or diabetic or in the stage of NPDR. The features extracted from the 30 images are given as input the NN classifier. In classification, The samples will be grouped into 3 parts (70%-15%-15%) for training, validation and testing respectively. After training we will get the confusion matrix that will give details of correctly classified and misclassified samples that is shown in the Fig.9.

The diagonal cells give the number of correctly classified images and misclassified images were shown by off-diagonal cells. We came to know from the blue cell at the bottom right that 96.7% of the images were correctly classified and 3.3% of the images were misclassified. By trying different algorithm or by changing the number of hidden neurons, we can able to obtain good results. It was observed that, out of 30 persons, 10 persons had diabetes, 9 had diabetic retinopathy, and 10 were healthy. The all confusion matrix gives all the above said details in a matrix format and thus it provides an effectual way of classification.

Fig.9.Confusion Matrix

V. Conclusion

The tongue images of 10 healthy persons, 10 diabetic persons and 10 NPDR persons have been captured using a high end digital camera. The captured images are preprocessed for noise removal, color correction and segmentation purpose. Then 13 geometrical features have been measured for all the segmented tongue images. The results are also trained and classified using ANN classifier.From the results it was found that, out of 30 patients, 10 patients were found healthy, 9 had NPDR and 10 had diabetes.Hence the results showed an accuracy of 96.7%.

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