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Palatal Rugae as a Parameter in Identification of Human being using Image Processing

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Abstract: ***The technology advancement has provided new opportunities to work in different disciplines of science. In the present paper, the problem of an identifying an individual is taken-up. The identity of an individual is required for many issues. Thus, the process of identifying an individual has been an open-end problem for all the fraternities. In the present work one such problem of identification of individual has been taken. Palatal rugae are irregular, asymmetric ridges of the mucous membrane extending laterally from the incisive papilla and the anterior part of the palatal raphe. The location of palatal rugae inside the oral cavity confers them with stability even when exposed to high temperatures or trauma.Their resistance to trauma and their apparent unique appearance has suggested there is a tool for forensic identification. Further, an Image processing tool has been used in the present work to create and distinguish between different samples. The process of data samples has been taken in collaboration with Dental experts.***

Keywords: Palatal rugae, Matching concept, Imaging filtering

1. Introduction

In this world of simulation, the identity of anyindividual is always questionable in situations ofmass massacres and disasters. A lot ofliterature is available on forensic odontology tools, but still this branch of odontology is in its infancystage in India.Establishing a person's identity can be a very difficult process in forensic identification. Dental, fingerprints, and DNA comparisons are the most common techniques used in this context allowing fast andsecure identification. However, since they cannot be always used, sometimes simple techniques can beused successfully in human identification, such as 'Palatal rugoscopy', which is the study of palatal rugae.Palatal rugae have been equated with fingerprints and are unique to an individual.[5]

It can be of special interest in edentulous cases and also in certain conditions where there are no fingers to be studied, such as burned bodies or bodies that underwent severe decomposition.Their resistance to trauma and their apparent unique appearance has suggested their use as atool for forensic identification.

A large amount of data can be stored and quick retrieval of information will be possible which may assist in immediate and effective identification of an individual. It would be beneficial to conduct further studies in large samples and taking more parameters for palatal rugae analysis in all races of the world, so that a national data can be prepared. The palatal rugae pattern can act as a fingerprint inidentification of a person. The analysis of palatal rugae combined with other methods is an important alternative and complementary technique for human identification.[4]

The shape of rugae was compared between the two study groups and was found to be highly significant between western Indian and northern Indian subjects. The number and shape of rugae differed significantly between the genders, with males having a highly significant difference as compared to the females. The western Indian group showed wavy shape predominantly in males and females had straight rugae. Similarly, the northern Indian male participants also had wavy shape; however, females in this group had more curved shaped rugae. [2]

2. Problem Statement

To implement techniques of image processing to enhance the pattern of palatal rugae.Theuniqueness of palatal rugae pattern can be utilized similar to fingerprints and when combined with other methods, it canhelp in the identification of a person.Thus these unique characteristics of the palatal rugae can be studied and can be enhanced a using Image processing and can be used as identity for the each individual. By using the data samples of palates of different individual, uniqueness of the identity can be recognized. The image processing techniques can be applied to these data samples to get the desired result.

3. Background

This study was undertaken to study and record the rugae pattern with respect to biometric characteristics of shape, size, direction, number and position in a cross section of the population in Uttar Pradesh. The individuality of the rugae pattern and their correlation with sex of the individual was also evaluated. Identification is the establishment of identity of an individual.

The basis of dental identification is based on the observation that no two individuals can have same dentition. Palatal rugae are irregular, asymmetric ridges of the mucous membrane extending laterally from the incisive papilla and

the anterior part of the palatal raphe. The location of palatal rugae inside the oral cavity confers them with stability even when exposed to high temperatures or trauma [3].

This paper consists of observation and compares the distribution of various palatal rugae patterns in western and northern Indian populations and to study the variations in male and female subjects respectively. The study consisted of 100 subjects, 50 each from the two groups of geographically different regions of western and northern India. After obtaining informed consent, an alginate impression of maxillary arch was made for interpretation. The uniqueness of palatal rugae pattern can be utilized similar to fingerprints and when combined with other methods, it can help in the identification of a person.Literature review shows that the two different populations of the geographical regions of western and northern India which were selected for the present study by the researchers were never studied earlier. The low-cost utilization, simplicity, and reliability have added strength to the study [6].

In the literature, the consensus of opinion is that the rugae remain fairly stable in number and morphology except when there is trauma, such as loss of tooth, persistent pressure, extreme finger sucking, orthodontic tooth movement, which may modify the alignment. Palatal rugae are irregular, asymmetric ridges of the mucous membrane extending laterally from the incisive papilla and the anterior part of the palatal raphe. The uniqueness and the overall stability of palatal rugae suggest their use for forensic identification.Thomas and Kotze (1983) studied the rugae patterns of 6 South African populations to analyze the interracial difference. They found that rugae were unique to each ethnic group and that it can be used successfully as a medium for genetic research [1].

4. Methodology: Architecture of identification of image patterns

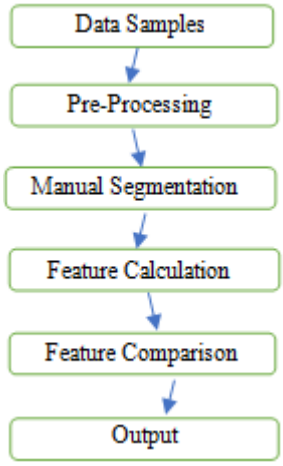


Figure 1: Process Flow

Data Samples: The sample consists of 21 subjectsbetween 18 and 25 years. Maxillary impressions were made with elastomeric impression material and dental stone was used to make models. The palatal rugae patterns were traced and analyzed with a Digital Camera.The samples were collected under the supervision and expert advice of dentist. These samples were coded with numbers for easy understanding of the different individual samples.

Figure 2: Data sample 7 Palatal rugae

Reading image in the workspace of MATLAB: In this step, we store the path to our image dataset into a variable then we created a function to load folders containing image into arrays.

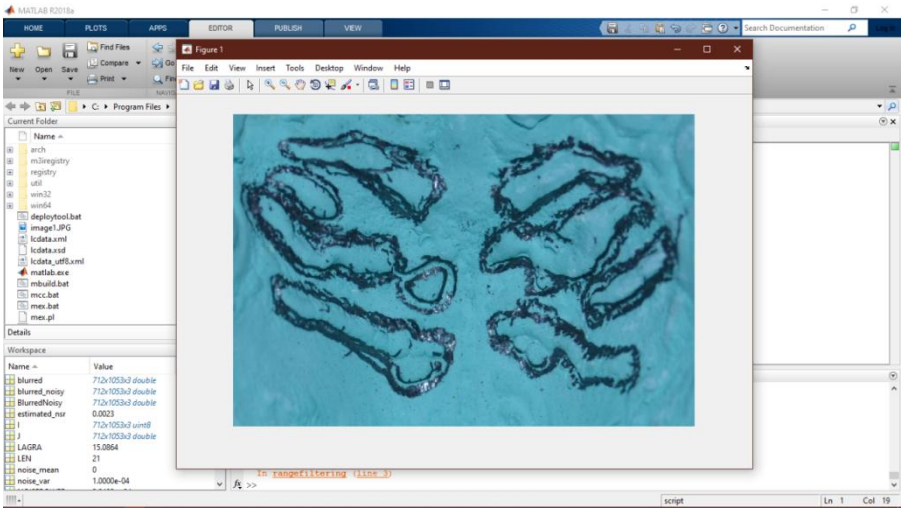


Figure 3: Reading Image into the Workspace of MATLAB

5. Experimentation

Image enhancement process of adjusting digital images are more suitable for display or further image analysis. For example, you can remove noise, sharpen, or brighten an image, making it easier to identify key features.The steps we have taken to achieve Enhanced and Filtered image are:

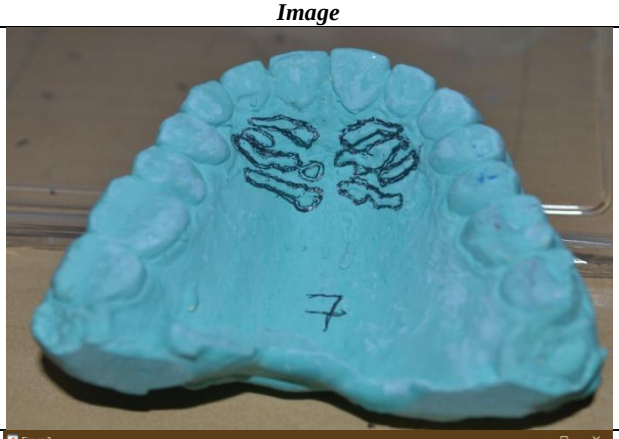
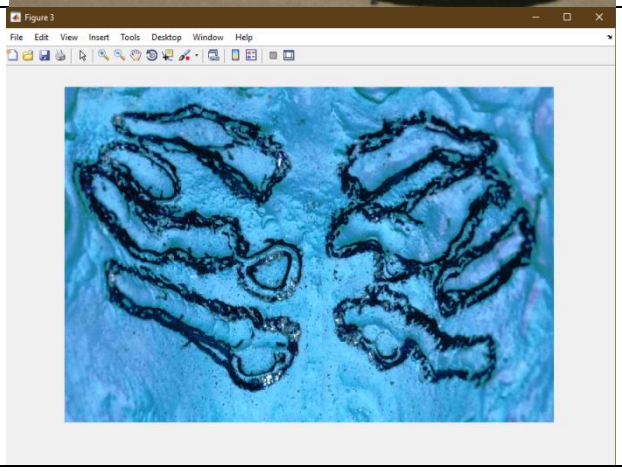
Histogram Equalization: Histogram of an image, like other histograms also shows frequency. But an image histogram, shows frequency of pixels intensity values. In an image histogram, the x axis shows the gray level intensities and the y axis shows the frequency of these intensities. After applying histeq function for the *Table 1.c* we get the enhanced image which all the intensities are equalized this is called Histogram Equalization which can be seen in *Table 1.d***.**As you can see from the graph, that most of the bars that have high frequency lies in the first half portion which is the darker portion. That means that the image we have got is darker. And this can be proved from the *Table 1.d.*

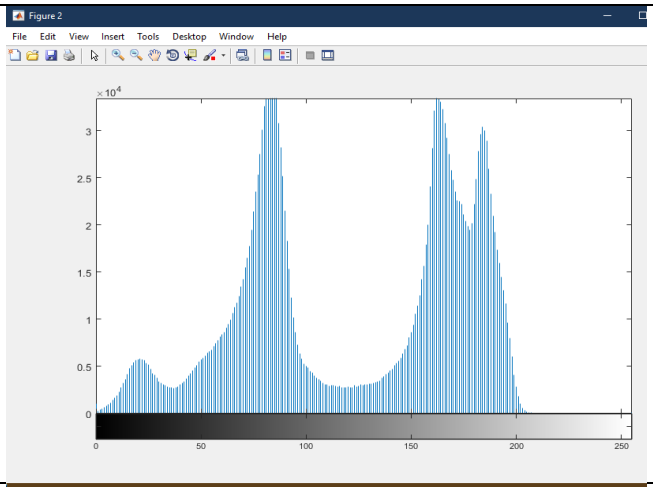
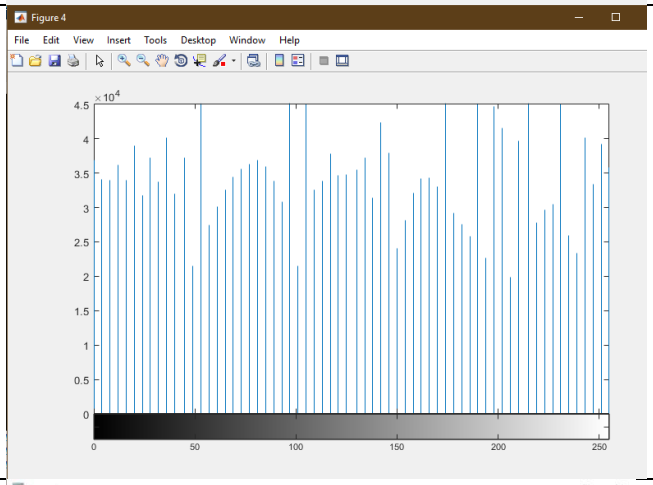
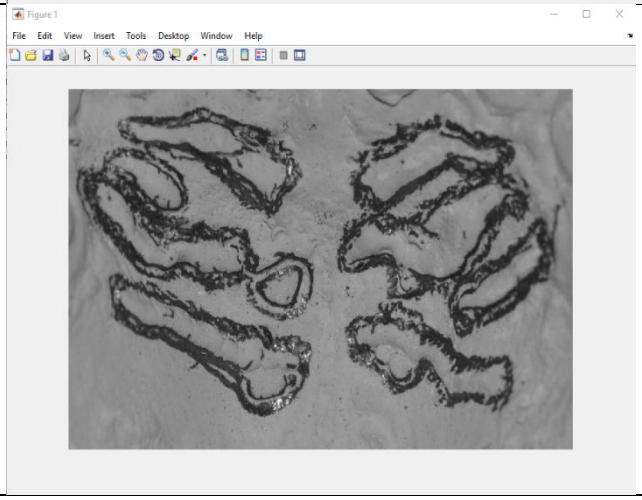
Manual Segmentation and Cropping: In this paper, we have used segmentation technique based on the pattern that have been classified using classification of Thomas andKotze and the shape was recorded based on Kapali*et al*.'s classification. Image segmentation is a commonly used technique in digital image processing and analysis to partition an image into multiple parts or regions, often based on the characteristics of the pixels in the image. Image segmentation could involve separating foreground from background, or clustering regions of pixels based on similarities in color or shape.

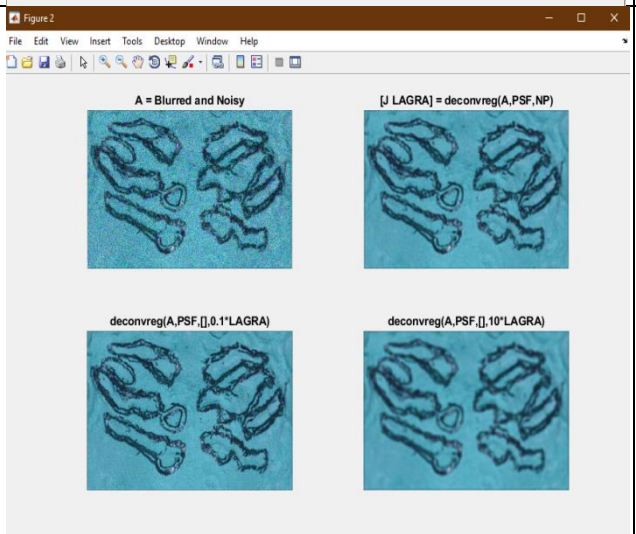
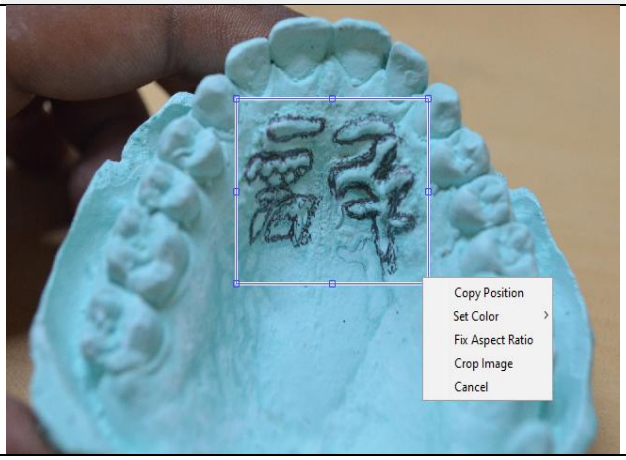
Cropping of the Image (imcrop). The "imcrop" function is used to crop the enhanced image based on the region of interest identified using the segmentation. imcrop creates an interactive Crop Image tool associated with the image displayed in the current figure. The Crop Image tool blocks the MATLAB command line until you complete the operation. The Crop Image tool is a moveable, resizeable rectangle that you can position over the image and perform the crop operation interactively using the mouse.

Conversion of Gray to Black and White (Binary) Image: We use *"imbinarize"* function to convert grayscale image to binary image or black and white image. *Imbinarize* (I) creates a binary image from 2-D or 3-D grayscale image I by replacing all values above a globally determined threshold with 1s and setting all other values to 0s. By default, *imbinarize* uses Otsu's method, which chooses the threshold value to minimize the intraclass variance of the thresholder black and white pixels. *imbinarize* uses a 256-bin image histogram to compute Otsu's threshold.

The functions used for various process
a) Gray conversion
b) Pre-processing using median filter
c) Cropping the image
d) Convert the image into black and white
e) Area calculation using pixels

Sl .No	*Image*	*Process*
1a		***Data Sample***
1b		***MatlabR2018aas tool for sample extraction***

1c		*Histogram of sample image*
1d		*Histogram Equalization Process*
1e		*RGB To Gray Conversion:*

1f		***Median filtering Process***
1g		***Regularized Filter Processing***
1h		***Cropping of Image using Crop Interactive Tool (imcrop function)***

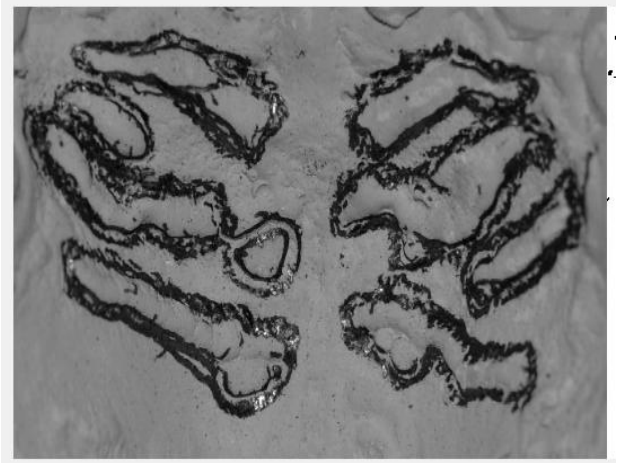
1i		***Image Enhancement***
1j		***Conversion to Binary image***

Table 1: Illustration of various stages of sample analysis

Algorithm to Calculate Area of palatal rugae pattern:

Input: Binary (black and white) image of the Region of Interest i.e. Palatal rugae pattern.

Output: Area of the ROI i.e palatal rugae pattern pixels.

Step 1: Invert the Black and white image i.e Binary image. So that Black pixels of the image are converted to White pixels and White pixels to Black.

BW= ~BW where BW is Binary image.

Step 2: Rows and Columns are calculated using size function.

[r, c] = size (BW)

Step 3: Black and White pixels count is initialized to 1.

Step 4 : Use the for loop to iterate to the last row and use another for loop inside the first for loop to iterate till the last column

for i=1: last row (r)

for j=1: last column (c)

if BW(i,j)==0

Increment Black pixel count by 1;

else

Increment White pixel count by 1;

Step 5: *Print the white pixel count i.e. Area of the palatal rugae pattern*

Further, the entire process has been carried out by taking the Original Image (RGB) into the workspace and is converted to the Grayscale Image and then the Gray scaled image is enhanced using the Median Filter. The *imcrop* function using Crop Interactive tool provides various functions in the menu such as “copy position”, “Crop Image” and so on. The Crop Image function is selected to crop the image according to the Region of Interest.Then cropped image is being displayed and this image is converted into the Binary (Black and White) pixel image. The process of inverting the Black and White image and calculating the white pixel count in the image that is Area of the Palatal rugae pattern is performed. The entire process of selecting a sample and comparing the same with the other samples has been done using Python Console Window used for the displaying the output and also provides the option for taking the input values.The calculated values (area) are different from each sample, thus indicating that the individuals aredistinct and clearing unique. The same has been presented in *figure 4*.

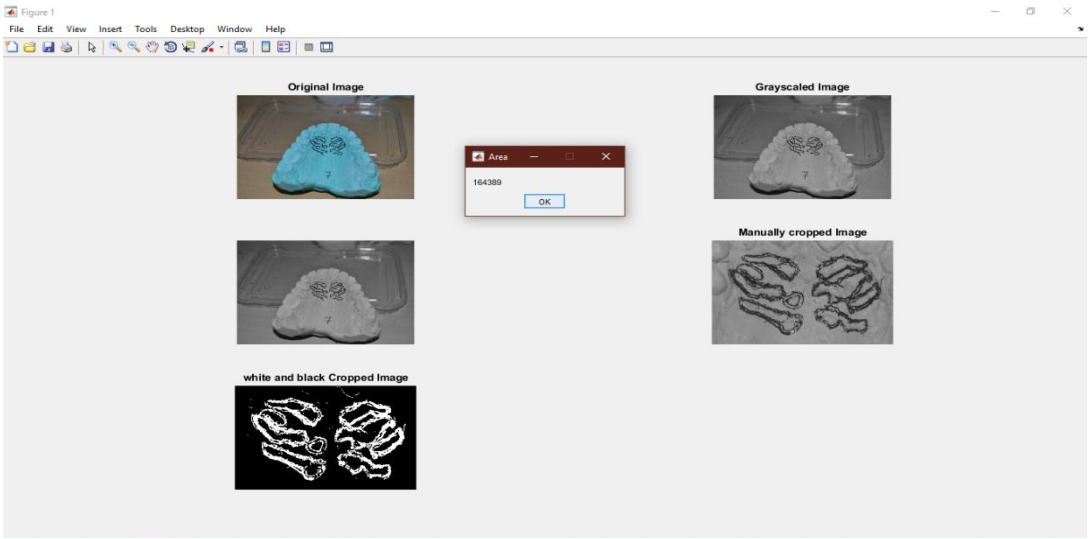


Figure 4: Calculation of Area of palatal rugae pattern

Table 2: Presents the area computed from each sample extracted

Sample	*Area*	*Sample*	*Area*	*Sample*	*Area*	*Sample*	*Area*
1	380600	6	76214	11	87193	16	89920
2	1077843	7	164389	12	136209	17	79558
3	100043	8	85047	13	87345	18	99876
4	115504	9	147055	14	62740	19	76358
5	150095	10	576057	15	65308	20	76205

6. Conclusion

In the present project work, we have palatal rugae which is a unique identity of an individual present in an upper jaw of mouth. The work has been done under the supervision of dental expert to understand the dental issues related to *Palatal Rugae*. The process of sample collection has been done by the dentist. A total of 200 samples were collected for the process. Out of 200 samples the best 20 samples were selected for computational algorithmic process.

As presented in the methodology, the samples were from the age groups of 18 to 25. The pre-processing stages (Image processing) were implemented for identifying shapes present in palatal rugae. In *figure 1*, the selection of one such sample has been used to work as a case study. The Matlab has been used as a tool for shape recognition. The Histogram Equalization concept presented the Intensity of the pixel present in the palate. Further, the Median Filtering process was taken up to reduce the noise and preserve the edges of the shapes as presented in *Table1f and Table 1g*respectively. In continuation the *crop*function was used to select the region of interest and **Otsu's** method was used to binarize the image.

In the next stage, the total area in which the shapes are present was computed to obtain the region of interest. The algorithmic for computing has been presented in *Table 1j*. Further, the samples were compared to identify the matching/distinct property between all the samples. This was done using ***python language***.

The entire process of converting a cropped image to binary image and computing the computation of area of shape (Palatal) is presented in *figure 3*. The overall calculated area for all the 20 samples is presented in *Table 2*. This clearly indicates that the overall area of each sample *(human Identification)* is distinct and clearly separable. This also indicates the uniqueness of every individual. The outcome of all the samples can be grouped based on age, gender which depends on the shapes present in thePalatal Rugae.

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