

# An Efficient Palatal Patterns Based Methodology for Identity Verification of Identical Twins

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## *Abstract-*

The learning and analysis of palatal patterns for verifying the identity of an individual is termed as palatoscopy or palatal rugoscopy. Since, dizygotic twins (fraternal twins) are generated from two different eggs at the time of fertilization. Therefore, the fraternal twins differ from each other in their face structure and gait signature etc. But, the identical twins are generated from the same egg. Hence they share the same DNA sequence and same face structure.

It is almost impossible to identify identical twins (monozygotic twins) on the basis of their face structure or DNA sequence or gait signature. But, it is observed that they can be differentiated / identified on the basis of their palatal rugae patterns. This research paper presents a novel mathematical model for identifying identical twins on the basis of their palatal patterns structures. The palatal curves of identical twins are represented by unique symbols and curve tracing based approach is used for comparing the palatal patterns of two different pairs of identical twins in the proposed mathematical model.

The author has used self generated data set of five pairs of identical twins palatal patterns for developing the proposed mathematical model where ten images of each person of identical twin pair were taken into considerations. The experiments and the corresponding results reveal that the proposed mathematical model of palatal curves based identification of identical twins is clearly able to identify the identical twins with high accuracy (above 90%).

*Keywords- Bifurcation Points; Trifurcation Points; Identifying Identical Twins; Palatal Patterns; Orientation Angle.*

## I. Introduction

Human being has come a long way from the early caveman age to the present day of covering, nothing less than astronomical heights to sea bed depths. Their will to conquer new heights has created a world full of scientific advancement and technology. However, their intelligence has also led to increase in crime rate, terrorism, wars, mass disasters, road traffic accidents and dreadful diseases. Hence, in such situations human identification will be a

great challenge. Human identification is useful for forensic science to identify human relationship at different stages. Identification is a set of characteristics and functions which differentiate an individual from others. There are number of methods which are used to identify an individual such as Signature, Finger prints, Finger veins, Palm prints, Palm Geometry, Palm veins, Heart Beat, DNA test, Iris, Lip-print, Face recognition, Ear-structure and Palatal rugae pattern etc [1][2] [3] [4].

In many cases the common methods of identifications e.g. finger prints, palm prints, Iris, face-recognition, lip-print etc. are not the secure way of identifying an individual. Further, in case of Terrorism, road-traffic accidents, dreadful diseases etc. the means of identification being an external part of the body may be destroyed due to the diseases or by an individual itself. Therefore, instead of using classical method of identification we can use palatal rugae pattern based identification approach [5] [6].

Palatal pattern term was first described by Winslow in 1753. Brubib (1983) followed the studies of Carrea and divided palatal rugae into two groups namely fundamental and specific. The study of palatal patterns for identifying a person individual is known as Palatoscopy or Palatal rugoscopy. The palatal patterns start developing in the three months of intrauterine life. The different studies reveal that palatal rugae pattern is extremely unique for an individual as the finger prints and it can be safely used for identification [1] [3] [7]. If once the palatal pattern is formed then it will remain at the same position throughout life but it may be possible homogeneous changes in its length because of normal growth. In special case if it is destroyed then also it will be reproduced in natural way at the same position [2].

Palatal Rugoscopy is an identification technique which was first proposed in 1932 by a Spanish investigator and it is also called as Rugaepalatina or Plicapalatinae transverse. It refers to irregular and asymmetric muscular located at anterior third part or palate mucosa on each side of the median palatal raphe and behind the incisive papillae. Palatal rugae are irregular, asymmetric ridges of mucous membrane extending lateral from the incisive papilla and the anterior part of the median palatal raphae, which is just

behind the maxillary central incisor teeth. They are well protected from trauma and are insulated from heat by the lips, tongue and buccal fat of pads [8] [9] [10].

A pair of identical twins (monozygotic twins) may have the same facial structure and the DNA sequence. Therefore, it is difficult to identify identical twins on the basis of face structure or DNA sequence. However, fraternal twins (also called dizygotic twins develop when two separate eggs are fertilized by two different sperms) may be differentiated by using the existing technologies with some perfection [4] [7] [11] [12].

## II. Literature Review

The researcher Harjeet et al.[6] conducted a study to record the biometric characteristics of shape, size, direction, number and position of palatal rugae and analysed whether palatal rugoscopy can be used as a tool for personal identification and for sex determination using Thomaz and Kotz classification or not.. They found that the average number of rugae were little more in females than males. The wavy (44.9%) and curved (41.8%) shapes were more prevalent in females. Therefore, these researchers came to a conclusion that rugae patterns are highly individualistic in nature and can be efficiently used as a supplementary method for personal identification and sex determination.

The researcher Madhusudan K et al. [9] aimed to assess the association of palatal rugae pattern for family members. They found that the Palatal rugae patterns of offspring were alike to either of their parents. The contingency coefficient test suggested positive correlation in direction patterns, between off spring and their parents. They concluded that the comparison of palatal rugae patterns within members of the family might give valuable indications for the identification and it may help in determining family lineage of a person.

The researcher Rezwana et al.[13] conducted a study to evaluate the individualistic nature and use of palatal rugae patterns for personal identification. These researchers also tested the efficiency of computerized software for forensic identification by photographic superimposition of palatal photographs obtained from casts. The image superimposition was performed with Adobe Photoshop 8.0 software. However, their proposed method has some limitations such as improper positioning of digitized photographs, and manual plotting of palatal rugae. They

concluded that palatal rugae are unique for an individual and can be used for human identification by using the digitized method of photographic superimposition.

The researcher Theodosia N. Bartzela et al.[14] conducted a study to characterize tooth agenesis patterns and their overall occurrence in patients with complete unilateral cleft lip and palate (CUCLP). Agenesis of at least one tooth was found in 48.7%, and agenesis outside the cleft was observed in 20.9% of patients. The lateral incisor of the maxillary cleft quadrant was the tooth most frequently missing (39.1%), followed by the maxillary lateral incisor (8.7%), and the mandibular second premolar (7.8%) in the non-cleft quadrants. Maxillary and/or maxillary and mandibular second and/or first premolars were involved in all patterns. A higher prevalence of tooth agenesis was observed in patients with CUCLP feature. Thirteen different patterns were observed, out of which it was found that only six were unique patterns.

## III. Proposed Mathematical Model

Let us suppose a universal set (U) comprising of 'n' groups of Twins where n is any positive integer. The set can be represented as:

$U = \{T_{1j}, T_{2j}, \dots, T_{(n-2)j}, T_{(n-1)j}, T_{nj}\}$  where  $j = \{1, 2\}$  and  $T_{ij}$  represents the person  $j^{\text{th}}$  of group  $i^{\text{th}}$ . Now, we consider the following aspects of palatal rugae pattern to establish a relationship between two persons within a group and among the groups [13, 14, 15]:

*Aspect 1:* The palatal rugae pattern of two persons within a group can have same positioning of the particular pattern or there may be symmetry.

*Aspect 2:* The palatal rugae pattern differs in shape, numbers (either in the left or right side), and the nature of Divergence / Convergence.

*Aspect 3:* The depth and width of Palate can also differ in person to person.

These aspects can be implemented to identify a person within a group of identical twins. The observed patterns for identifying identical twins are: straight line pattern, wavy pattern, circular pattern, bifurcation pattern and curves. These patterns can be represented by fig. 1 [15] [16] [17].

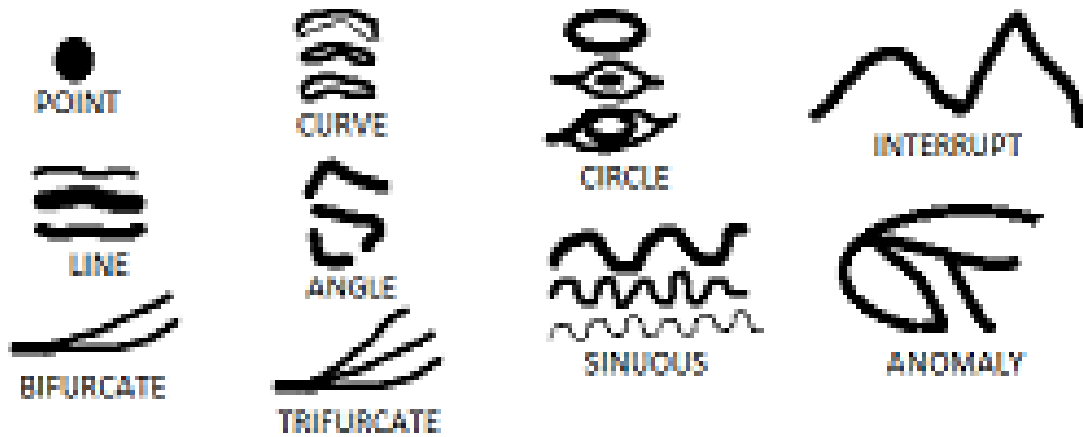


Fig. 1: Palatal pattern structures of identical twins [15] [16] [17].

The different observed shapes of palatal patterns can be represented by Eq.(1), Eq.(2) and Eq.(3).

$$ax + by + c = 0 \quad (1)$$

$$y = a \sin(bx + c) \text{ where } A \neq 0 \quad (2)$$

$$ax^2 + by^2 + 2gx + 2fy + c = 0 \quad (3)$$

In case of bifurcated pattern, we can divide the pattern into three sections of straight lines which is represented by lines is AB, BC and CD where 'B' is the bifurcation point. Further, the equation of line AB, BC, and BD can be obtained if the coordinates of point A, B, C and D are known.

Table 1: The possible types of complex curves for representing the palatal patterns of identical twins [17] [18] [19]

Classifications	Rugae Type	Shape
TYPE A	POINT	
TYPE B	LINE	
TYPE C	CURVE	
TYPE D	ANGLE	
TYPE E	SINUOUS	
TYPE F	CIRCLE	

The equation of curve pattern can be obtained as the sections of ellipse or parabola or ellipsoid etc. Hence, if these equations are known to us then we can determine whether the two shapes are different or not [18] [19].

Now, consider the straight pattern of Type B (in table 1) observed in Person  $P_{ij}$  of any fixed group (say  $i=k$ ) and  $j=\{1,2\}$ . Here  $x_{ij}$  represents the coordinate of patterns observed in person  $j^{\text{th}}$  of group  $i^{\text{th}}$ . The equation of pattern of Type B by assuming it to be nearly straight line can be written as Eq.(4) and Eq.(5).

$$(y - y_{1j}) = \left( \frac{y_{2j} - y_{1j}}{x_{2j} - x_{1j}} \right) (x - x_{1j}) \quad (4)$$

$$\text{or } (y - y_{1j})(x_{2j} - x_{1j}) = (y_{2j} - y_{1j})(x - x_{1j})$$

$$\text{or } y(x_{2j} - x_{1j}) + x(y_{1j} - y_{2j}) + y_{1j}(x_{1j} - x_{2j}) + x_{1j}(y_{2j} - y_{1j}) = 0 \quad (5)$$

After comparing the coefficients of x, y in Equations (1) and (5), we get

$$a = (y_{1j} - y_{2j}) \quad (6)$$

$$b = (x_{2j} - x_{1j}) \quad (7)$$

$$c = (x_{1j}y_{2j} - x_{2j}y_{1j}) \quad (8)$$

Now, we generalize the coefficient a, b, c of Eq.(6), Eq.(7) and Eq.(8) for the Universal Set U using Eq.(9), Eq.(10) and Eq.(11).

$$a_{ij} = (y_{1j}^{(i)} - y_{2j}^{(i)}) \quad (9)$$

$$b_{ij} = (x_{2j}^{(i)} - x_{1j}^{(i)}) \quad (10)$$

$$c_{ij} = (x_{1j}^{(i)}y_{2j}^{(i)} - x_{2j}^{(i)}y_{1j}^{(i)}) \quad (11)$$

Here, we can conclude that either if  $(a_{ij} > a_{(i+k)j})$  or  $a_{(i+k)j} > a_{ij}$  or  $b_{ij} > b_{(i+k)j}$  or  $b_{(i+k)j} > b_{ij}$  or  $c_{ij} > c_{(i+k)j}$  or  $c_{(i+k)j} > c_{ij}$  then the pair of straight lines are different. Hence two patterns represented by these lines are different for any two Person within the group or for the group  $i^{\text{th}}$  and  $(i+k)^{\text{th}}$ .

Now, we consider the wavy pattern. If we magnify the obtained palatal image to a large extent we find that the patterns are Sinusoidal of Type E as given in Table 1.

The observed sinusoidal pattern can be represented by equation (12).

$$y = a \sin(bx + c) \text{ where } A \neq 0 \quad (12)$$

Now, consider the  $j^{\text{th}}$  persons of the  $i^{\text{th}}$  group, the observed Palatal pattern equation be given as:

$$y_j = a_j \sin(b_j x + c_j) \text{ where } a_j \neq 0 \quad (13)$$

After differentiating Eq. (8) with respect to 'x', we get Eq.(14) and Eq.(15).

$$\left(\frac{dy}{dx}\right)_j = a_j b_j \cos(b_j x + c_j) \quad (14)$$

$$\text{or } \left(\frac{dy}{dx}\right)_j = X_j \cos(b_j x + c_j) \text{ where } X_j = a_j b_j$$

$$\text{or } D_j = X_j \cos(b_j x + c_j) \text{ where } D_j = \left(\frac{dy}{dx}\right)_j \quad (15)$$

The author has mathematically represented curve patterns of each person of the identical twin pair for the purpose of identification in the equations from Eq.(1) to Eq.(15). The experiments and the corresponding results reveal that the proposed mathematical model of palatal curves based identification of identical twins is clearly able to identify the identical twins with high accuracy (above 90%).

## IV. Conclusions

This research work describes a novel mathematical model for identifying identical twins on the basis of structure of their palatal patterns. The palatal curves of identical twins are represented by unique symbols and curve tracing based approach is used for comparing the palatal patterns of two different pairs of identical twins in the proposed mathematical model. The author has used self generated data set of five pairs of identical twins palatal patterns for developing the proposed mathematical model where ten images of each person of identical twin pair were taken into considerations.

The total number of palatal rugae patterns remains constant provided that the external factors remain unchanged. In a sample set of two patterns, if there exists at least one axis of symmetry in one of the pattern and other do not possess any axis of symmetry then they belong to two different persons. The curve tracing and matching of different palatal patterns of identical twins ensure their identity verification with very high degree of accuracy.

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