



Review Article

Tongue prints- Unique as well as potential forensic tool for biometric authentication

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ABSTRACT

Forensic odontology proves to be an important branch of science when it comes to solve various criminal cases as well as in person identification by providing dental expertise in the court of law so that proper justice can be delivered. Tongue is an important vital organ of human body which is protected from outer environment as it is well encased within the oral cavity. Tongue has very unique features which differs from individual to individual, even in identical twins. For this reason, tongue prints can be used nowadays as a method of biometric authentication in Forensic Odontology. It also aids in identification of person as tongue exhibits sexual dimorphism. As a result of all this, tongue prints has emerged as a promising forensic tool nowadays.

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1. Introduction

Forensic odontology is a branch of science dealing with multidisciplinary approaches for the issues of law by providing dental expertise and thereby solving various cases. This branch helps to provide many information regarding gender determination as well as age determination, person identification in cases of disaster victim identification and many more. Tongue is a vital organ which has a number of actions which includes speech, taste sensation, formation of bolus. It has distinctive characteristics that vary from person to person and even amongst identical twins. Every person has a distinct colour, shape, and surface characteristics that can be used to identify them. Personal identity by biometric

authentication has grown in popularity in recent years. The need for security when dealing with financial information, transactions, etc. has sparked study in the area of biometrics. To identify the person in biometric authentication, the input sample is compared to a sample template.^{1,2}

Various biometric systems have emerged in various forms such as voice recognition, facial recognition, iris scanning, skin colour, signature verification, and fingerprint. Recently, interest in tongue prints as a biometric tool has increased. The look for the use of the tongue print as a means of biometric authentication resulted from the development of new personal identification methods. Tongue characteristics that display sexual dimorphism help to identify a person and hence the tongue is becoming an innovative biometric tool.³

Tongue prints guarantee individuality and feature a variety of qualities that make them useful for

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identifying people. Tongue prints are the best tool of the majority because they are more dependable and accessible. The diseases and malformations of the tongue are one of the few things that can hinder the use of the tongue print.^{4,5}

1.1. Normal structure of tongue

The tongue is a vital organ that carries out numerous functions, including speech articulation, taste perception, and food bolus production. It is confined in the mouth cavity and highly shielded from the outside environment. Stratified squamous epithelium covers the dorsal mucosal surface of the tongue. On the dorsal surface are also many papillae and taste buds. Four different papilla kinds can be found in different places which includes Circumvallate, Fungiform, Filiform and Foliate papillae. The majority of papillae are filiform, however they lack taste receptors.^{2,6,7}

Four intrinsic and four paired extrinsic muscles make up the voluntary muscular anatomy of the tongue. While the extrinsic muscles are attached to the bone and change the position of the tongue, causing it to protrude outward and move from side to side, the intrinsic muscles change the shape of the tongue and are not connected to the bone.^{6,7}

1.2. Different attributes of the tongue

Two features of tongue make up tongue recognition: Shape and texture.

1.2.1. Shape

This can be categorised into the following categories in Traditional Chinese medicine (TCM):

1. Rectangle
2. Acute triangle
3. Obtuse triangle
4. Square
5. Circle

The shape parameter is calculated using control points. This technique yields clear outlines of the tongue's form feature.

1.3. Texture

1. Physiologic
2. Fissured –Depth of the fissure up to 1 mm.
3. Pathologic
4. Geographic
5. Scrotal
6. Smooth
7. Hairy
8. Furrowing
9. Ulcers

The SIFT (Scale Invariant Feature Transform) Algorithm calculates the texture feature after pre-processing it with histogram equalisation.^{8,9}

1.4. Uniqueness of tongue

In forensic odontology, the tongue is the principal internal organ that may typically and readily be exposed for investigative purposes. An accurate confirmation of life is provided by the tongue inspection process. Each individual has a different shape and surface texture. Twins who are identical have varied tongues in terms of form, colour, and texture. And so, with more clarification, it can be applied as a novel technique for personal identification.^{1,10}

Since tongue is an internal organ, it serves as a proof of life, indicating if the individual is alive or dead, which highlights its uniqueness. A person can only protrude their tongue for inspection when they are still alive. Especially in cases of sleep apnea, the tongue can slip back and impede the airway, which frequently results in death. Second, analysis of shape, texture, and colour shows distinguishing characteristics between individuals, making it a useful tool for identification.¹¹

Examining the tongue's morphology reveals that it has a "U-shape" with a somewhat rounded off tip. The trapezoidal form of the tongue, which has a larger base at the level of the oral commissures and a smaller base on the anterior side⁸, was the other shape that was frequently observed. The most typical morphological feature of the tongue is the presence of fissures on its dorsum surface. According to a preliminary study, female individuals frequently exhibited a geographic tongue and sharp points, but male subjects frequently exhibited a septate tip. The tongue differs between the sexes in terms of breadth and length, with males showing a wider and longer tongue than females.^{1,2,10,11}

2. Tongue Prints in Forensic Odontology

Uniqueness is crucial for establishing a person's identity. Each person has a different dorsal surface of the tongue. Even between identical twins, the typical features of the tongue show notable differences. Lingual impressions have been shown to be helpful in forensic dentistry when used in conjunction with techniques like cheiloscopy and rugoscopy. Although the tongue is one of the primary components for diagnosis in TCM, its usage in natural and man-made disasters has not yet been recorded.^{2,3,12}

3. Tongue prints Vs Other Biometric Systems

A real-time identification system called biometric system measures a specific physical or behavioural trait of a person and compares it to a library of characteristics shared by numerous persons. Different biometric technologies are used for security objectives. They include fingerprint, retinal scan, skin tone, voice, palm, face, and signature checks, among others. These security measures come with benefits and drawbacks. Each system has drawbacks that make them susceptible to security breaches and difficult to identify users. Fingerprints are not stable since they can be worn

down, altered by work, changed by surgery, and subjected to wounds and burns. Sickesses like the common cold and the cough have an impact on the voice. Extreme emotional states have a tendency to lead to verbal slip-ups. The retinal scan is very perceptive. It depends on the user and can be harmed by harsh light, conditions like cataracts. Another sort of biometric is based on skin colour, however it has stability issues because there are significant variations with age, burns, illnesses, and the use of skin creams or drugs.

Using a tongue print has many advantages over other biometric methods like fingerprint, voice recognition, and retinal scan. Everybody has a different tongue, both in terms of form and surface roughness. It can be easily exposed for investigation because it is an internal organ, and the information needed is on the exposed surface. The physiological shape and texture don't change. Since it is adequately insulated from the outside environment, external variables do not impact it. It is also a trustworthy indicator of life. The use of tongue prints as a crucial instrument for biometric authentication has grown in recent years.^{13,14}

3.1. Application of tongue prints in forensic odontology

It has distinctive qualities like colour, shape, and surface characteristics that vary from person to person. It serves as a tool for personal identification because they differ amongst identical twins. The tongue's texture and shape are both used for identification. The exposed part of the tongue includes information that differs visibly from person to person; as a result, it aids in the identification of suspects during forensic investigations. The forensic evidence used to determine the cause of death is the tongue. Important drowning evidence includes a biting tongue in addition to bulging eyes, anus, and enlarged abdomen. The protrusion of the tongue is a sign of a hanging death, but a dark tongue is a sign of a poisoning.^{1,15}

3.2. Classification

When evaluating a living case, the tongue's vitality, colour, shape, wetness, and movement are all taken into account. The tongue's surface coatings are further categorised based on their colour, which is typically clear-white and has a thin, homogeneous layer. Changes in these traits represent sickness and can be used to make a diagnosis. Various authors have categorised the distinctive characteristics seen on the tongue's dorsal surface in various research, including:

Classification of characteristics of tongue's dorsal surface-

1. Textural variations in tongue
Tongue fissure or tongue crack smooth tongue
2. Shapes of tongue
 - (a) Elliptical
 - (b) Hammer

- (c) Rectangular
- (d) Acute triangular
- (e) Obtuse triangular
- (f) Square
- (g) Round

3. Tongue geometry features

- (a) Length
- (b) Width
- (c) Thickness

Tongue fissures are the numerous grooves or furrows that line the dorsal surface of the tongue. Either one groove or several grooves may be present. It's possible for the grooves to be shallow or deep. Smooth tongue is a tongue that has no fissures or cracks. By using the lingual tip and the lingual sulcus' V-shape as reference points, the tongue's form is examined. The existence of a fibrous band in the tongue's tip, a slight or partial fissure in the tongue's tip that seems to be a bifid tongue, and other variations have also been noted. Stefanescu et al. proposed a new categorization in 2014.

3.3. Classification of tongue features by Stefanescu et al

1. Tongue texture

- (a) Physiological
- (b) Scrotal
- (c) Geographic

2. Shapes of tongue

- (a) Ovoid
- (b) Ellipsoid
- (c) Rectangular
- (d) Pentagonal
- (e) Trapezoidal to asymmetrical

3. Longitudinal grooves

- (a) Perceptible/Imperceptible
- (b) Rectilinear / twisty
- (c) Superficial/ deep^{1,2}

3.4. Tongue print collection and identification

In a 2007 study at Hong Kong Polytechnic University, a tongue image database was developed. This database included both the geometric shape of the tongue and the surface textures of different people, and it was thought that this database would be a useful tool for assessment, comparison, and evaluation. There are numerous techniques to obtain tongue prints. A straightforward visual examination can show surface texture changes, tongue colour, and movement. Digital images of the tongue can be taken and their shapes can be verified by comparison with data stored in a database. The form of the tongue is evaluated by merging three reference points in

a three-dimensional study of the tongue, which is a valid choice for evaluation. By making an alginate impression of the tongue and then preparing a cast, analysis of the tongue can be accomplished. This aids in identifying the distinctive characteristics and duplicating them on a cast that may be used for research. The development of an appropriate algorithm for tongue image processing has been the subject of numerous studies. Other techniques includes 1. Since the tongue is a flexible organ, video of one should be captured and images extracted from it. 2. Sublingual vein analysis, one of the frequently used techniques for tongue diagnosis. 3. An ultrasound approach has been used to examine tongue function, using an ultrasonic transducer inserted in the sublingual region. 4. A tongue histological examination can also be done.^{1–3,16}

3.5. Sexual dimorphism

Personal identification is greatly aided by sexual dimorphism in tongue traits. Men and women have been found to have specific differences or variations in the properties of their tongues. Scrotal tongue and geographic tongue have been noted to be features of female patients. A study found that patients with sharp edges at the lingual apex were more likely to be female than those with septate tips. Men and women have different tongue lengths and widths, although it has been found that male patients' tongues were often longer and wider than those of female patients. The direction of the tongue's muscle fibres between men and women was significantly different when histologically investigated.^{12,13,15}

3.6. Future scope of tongue prints

Tongue prints are being taken and analysed using a variety of methods, such as spectrum analysis, Gabor filters, and wavelet transformers, all of which produce distinct outcomes. Images of the tongue can be used for the tongue print verification process once they have been preprocessed for texture and form analysis. The choice to verify and match the tongue is made once the shape vector and texture code scores have been compared. As a result, the complexity of data collection and analysis becomes a restriction because it necessitates the use of expensive tools and specialised knowledge. These constraints will be quickly removed by technological innovation, allowing simple usage of tongue prints in forensic dentistry in future.

4. Conclusion

The tongue is a special organ with numerous static and dynamic features that vary greatly between individuals. Use of tongue prints for biometric identification tool has been investigated, and investigations have revealed that it is advantageous and comparable to other biometric methods. The distinctiveness of tongue prints makes them a useful

tool for biometric systems and personal identification. Dentists can regularly use the procedure for tongue prints. A clue for personal identification can be found in the lingual photograph that the dentist keep as records. In this digital age, tongue prints have a bright future as a potential tool in forensic odontology.

5. Ethical Clearance

Taken from ethical committee of the college.

6. Source of Funding

None.

7. Conflict of Interest


None.

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