

Tongue Scanning As a Biometric Tool: A Review Article

Mrunmayee Godbole¹, Bindiya Narang², Sangeeta Palaskar³, Swati Patil⁴,
Anirudha R Bartake²

¹Ex-Student (Passed out), Sinhgad Dental College And Hospital, Pune, India

²Reader, ³Professor & Head, ⁴Lecturer,

Department of Oral Pathology & Microbiology, Sinhgad Dental College & Hospital Pune, India

Corresponding Author: Mrunmayee Godbole

ABSTRACT

Tongue is an essential internal organ, unaffected by the external environment as it is located well within the oral cavity. Dorsum of the tongue exhibits a great amount of information along with visual differences in shape, texture, and pattern. These patterns are characteristic of every individual and differ even between identical twins and they can be collectively called the 'tongue print'. Tongue printing has not only come up as a novel biometric tool but can also be trusted upon as a powerful forensic tool. This review throws light on the distinctiveness of tongue prints. It also emphasizes its advantages over other biometric identification systems and highlights the various methods that can be used to extract features on the tongue.

Keywords: Tongue print, biometric tool, tongue, features, reference point

INTRODUCTION

A person can be recognized based on a physiological or behavioral characteristic by automated methods like biometrics which is separate and distinct from personal information. A biometric system works by identifying a person by assessing specific physical attributes related to that person and compares it to an already existing library of databases belonging to many people. Thus, it is a real-time identification system.¹ Biometric devices include a scanning device or a reader. The scanned information is converted into digital form by a software. When converting the biometric input, specific points of data are identified as match points by the software. An algorithm is used to process it into a value that is compared with biometric data scanned when a user tries to gain access.¹ Recently, there has been an increased interest in tongue prints as a biometric and forensic tool.² Since it is specific to every individual and

does not change, it can be used for identification purposes as well as forensic purposes.

Forensic dentistry deals with the proper handling, examination, and evaluation of dental evidence which will be presented in the interest of justice.³

The different biometric systems that are employed for security purposes include fingerprint, retinal scan, skin color, voice check, palm print, face scan, signature check, hand geometry, vein, etc. The shortcomings of each system make it susceptible to a security breach and also pose a difficulty in identification purposes. Fingerprints can be eroded, changed due to work, altered by surgery, and subjected to injuries and burns, making them unstable, whereas, when voice is considered, it can be affected by ailments such as cold and cough, sore throat. In the case of extreme emotional states, there are chances of misspoken words and the pronunciation can be unclear

at times. Retinal scan is highly sensitive and user-dependent. Conditions such as cataract, astigmatism or bright light can affect it. Skin color is also identified as a type of biometric system, but the measurements can vary depending upon the age, burns, diseases, and use of skin creams or medications.⁴

As an alternative to bypass the above drawbacks, lately, researchers have taken a keen interest in using the tongue print as a method of identification in biometric authentication. Tongue is an indispensable organ that performs multiple actions such as articulation of speech, perception of taste, and formation of the food bolus. It is well protected from the external environment and enclosed in the oral cavity.² Every tongue has its own 'Lingual Impression' because of its unique shape and texture. Also, the tongue is well contained inside the body (precisely, the mouth), but it can easily be stuck out for inspection, but not without the subject knowing about it. What remains constant is the physiological shape and texture of the tongue.² Also, sticking out one's tongue is an irrefutable 'proof of life' and also assures of the person's consent, whereas fingerprints and even irises can be mimicked or applied without the person's consent/consciousness. Tongue prints assure to render uniqueness and have many characteristics that make it suitable for identity recognition.⁵ Tongue prints are more reliable and easily available, making them a better tool of the lot. One of the few factors that can hinder the tongue print includes the pathologies and anomalies of the tongue.

Normal structure of the tongue:

The tongue is a voluntary muscular structure composed of four intrinsic and four paired extrinsic muscles. The intrinsic muscles are not attached to the bone and bring about a change in the shape of the

tongue, whereas the extrinsic muscles are attached to the bone and bring about a change in the position of the tongue which includes protrusion and side to side movement of the tongue. The epithelium on the dorsal mucosal surface of the tongue is stratified squamous epithelium. Numerous papillae and taste buds are also embodied on the dorsal surface. There are four types of papillae present at peculiar locations. Filiform papillae are maximum in number but they lack taste buds.⁶ They are characterized by increased keratinization and are involved in the mechanical aspect of providing abrasion. Circumvallate papillae are arranged in an inverted V-shape behind sulcus terminalis towards the base of the tongue. Fungiform papillae are present mostly at the dorsal surface of the tongue, as well as at the sides. Foliate papillae are present towards the posterior part of the tongue found at the lateral borders.⁶ The dorsum of the tongue also displays fissures and crypts in certain individuals.

Different attributes of the tongue

Tongue recognition consists of two Features of Tongue; they are:

1. Shape
2. Texture

1. Shape⁷(Ref. Figure.1)

According to Traditional Chinese Medicine (TCM), the shape can be classified as:-

- Rectangle
- Acute triangle
- Obtuse triangle
- Square
- Circle

Control points are used to calculate the shape parameter. Prominent outlines of the shape feature of the tongue are obtained by this method.⁸



Figure.1 Different shapes of Tongue⁷

2. Texture (Ref. Figure.2)

- Physiologic
 - Fissured –Depth of the fissure up to 1 mm.
- Pathologic
 - Geographic
 - Scrotal
 - Smooth
 - Hairy
 - Furrowing
 - Ulcers

Texture Feature is calculated by SIFT (Scale Invariant Feature Transform) Algorithm which is Pre-processed by Histogram Equalization.⁸



Figure.2 Different textures of Tongue⁸

Methods used for tongue printing:

Tongue print is unique for every individual and hence, a promising new biometric tool. It is very difficult to forge. This review features various methods used in previous studies on tongue printing.

In a study carried out by CLStefanescu et al, the various aspects of lingual morphology were preserved using the alginate molding technique, which is considered to be the most assured technique for duplicating the intricate details. In this study, photographs of the participants' tongues were taken from the front and side view, using a professional Nikon D 5100 camera placed on a tripod, under the same environmental and lighting conditions and from a predetermined distance and a database was created that contained 824 pictures of the respective subjects' tongue. It was found that from a sexual dimorphism standpoint, scrotal and geographic tongue was more prevalent in female subjects and the lingual apex showed sharp tips, whereas septate tips were more commonly found in male subjects.⁹ A similar study carried out by Vijay P et al showed similar findings

concerning the predominance of scrotal tongue in females while a contradiction was seen in the occurrence of geographic tongue, more being presented in the males than the females.¹⁰

In a similar study carried out by T.Radhika et al, it was revealed that the length and width of the tongue differed between males and females, with males having an increased length and width compared to females. The shape of the tongue was obtained by joining three reference points.²

A study was carried out at Hong Kong Polytechnic University in 2007 by Liu Z et al. It aimed at developing a tongue image database. It encompassed both-tongue geometric shape and surface textures of individuals, and this database was assumed to be a valuable resource for assessment, comparison, and evaluation.¹¹

Another viable option for assessment is a three-dimensional analysis of the tongue. The color and hue can be autocorrected by digital software. Feasible matching of images can be achieved by using Mean Squared Error (MSE) detection in colored pixels of the tongue images. To seek higher accuracy, the images are analyzed using different filters.¹²

The positional alterations and the camera conditions are checked, followed by analysis of the tongue for its color and texture. It is then matched with its database to bring about identification. A lot of studies have been scrutinized to compile a proper algorithm for tongue image analysis.⁷ The tongue is a nonrigid organ, attempts were made to capture the video of a tongue and extracting images from the same. Sublingual vein analysis is another common method employed for tongue diagnosis.¹³ A different method that consists of an ultrasound transducer placed in the sublingual area is also used to assess the function of tongue.¹⁴

In a pilot study carried out by Nadeem Jeddy et al, digital photographs (front and side view) of the participants' tongues were taken after visual inspection of the dorsal surface of the tongue,¹⁵ followed

by alginate impressions and pouring of the casts.¹⁶ Cases excluded from the study were the patients with a habit of smoking and any systemic illnesses. Two observers separately analyzed the photographs and the casts and examined the intricate details of the surface morphology including shape, presence or absence of fissures and its pattern of distribution. Three reference points are taken into consideration to deduce the shape of the tongue. They include the part of the tongue in contact with the commissure of the lips (when protruded outside the mouth) and the tip of the tongue.^{5,16} The presence of central fissures was the most common morphological characteristic observed on the dorsum of the tongue. The males showed multiple vertical, shallow fissures whereas the females showed a single deep vertical fissure. Predominantly, U shaped tongue was seen in both, males and females. V-shaped tongue was observed in 25% of females.^{15,16,17} Scalloped borders were more common in females compared to males.¹⁵

In a study carried out by D. Zhang et al, a tongue image database was created using sample images collected from 134 people. A 93.3% recognition rate was produced qualifying the tongue prints as a feasible new member of the biometrics family.¹⁸

A summary has been made and presented in Table 1 which includes the methodology and their respective outcomes.

Another level of precision is added to personal identification and authentication when the tongue print analysis follows the conventional sequence of identification steps for the study:

- Image acquisition
- Image registration and authentication
- Feature extraction and enhancement
- Matching
- Decision making¹⁹

A high-end digital camera installed with an exceptional detail-capturing sensor called CCD EXR is used for the tongue image acquisition. It offers excellent image

quality, where this sensor allows a '3-in-1' sensor combination of 'Fine Capture Technology' (High Resolution). It reproduces the subject's most minute detail in bright beautiful and vivid colors. 'Pixel Fusion Technology' is a Micro-receptive and extremely Low Noise technology that shows subtle shades and subject's details even in high contrast light. On the other hand, 'Dual Capture Technology' is a Wide Dynamic Range, capturing the subject with a smooth texture and natural brightness free from noise. EXR promises a high degree of reproduction and replication in imaging with an innovative color filter array and image processing technology, providing an exceptionally balanced quality and capturing the image, just the way as the human eyes perceive it.⁸

The tongue image extraction module consists of capture tongue images, images of tongue in database, spots on the tongue, display scale setting, read pixel, zoom in and zoom out.⁸ Detailed diagrammatic explanation of the tongue print verification procedure and tongue print set-up has been picturized in Figure.3 and Figure.4 respectively.

Various methods have been tried for recognition of the tongue images such as spectral analysis, Gabor filter, and wavelet transform have been tried, each of it delivering a different result.¹⁸ A form of discrete wavelet transform is the Dual tree complex wavelet transform (DT-CWT). DT-CWT extracts the unique features (size, shape, and textures) from each provided tongue image and stores the results in the Tongue-print image database. Two wavelet trees are used in dual-tree, both effective in perfect reconstruction (PR). The disadvantages of DWT are taken care of in DT-CWT and thus DT-CWT gives better results as compared to DWT.¹⁶ More precise results are extracted from the system using the DT-CWT algorithm hence contributing in the authentication process more efficiently. Errors generated in noisy sensors or communication channels often corrupt

the images by noise. DT-CWT overcomes this drawback and renders the better denoising of an image in real-time environment.²⁰

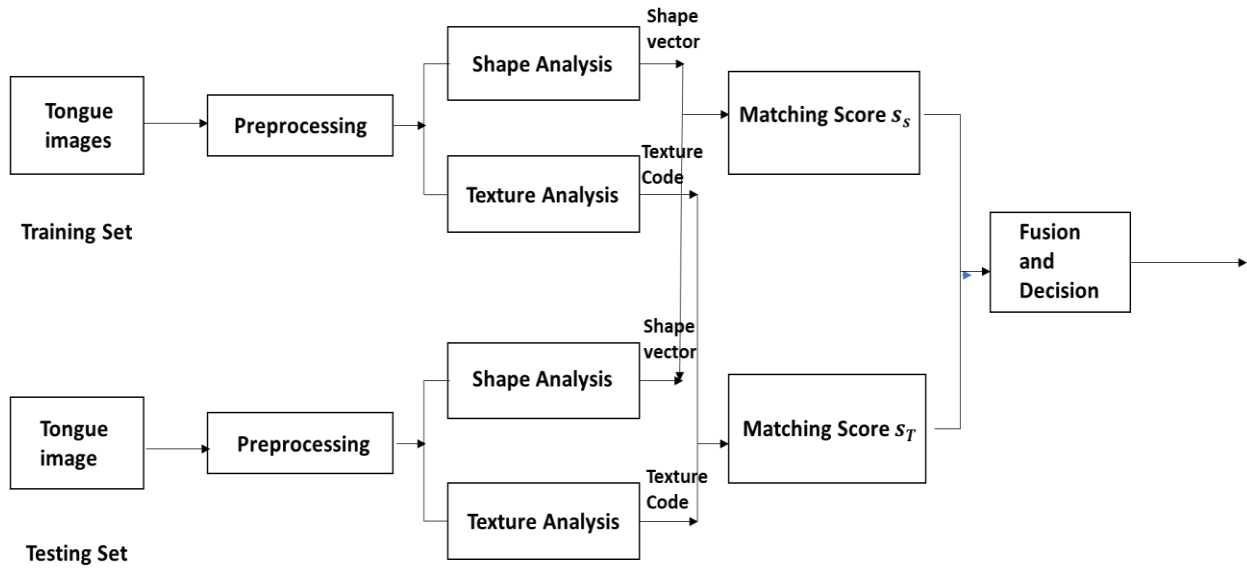


Figure 3. The block diagram of the tongue-print verification procedure¹⁸

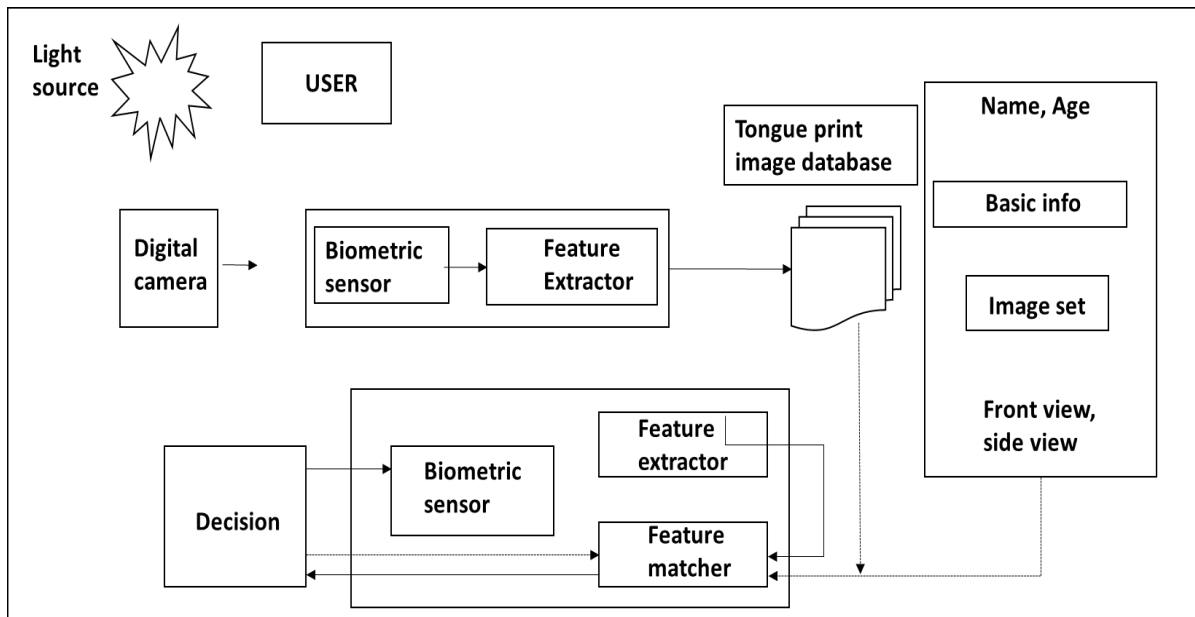


Figure 4: Biometric tongue-print system setup⁸

Table 1: Summary of Previous studies

Sr.no	Author	Method	Results
1.	CL Stefanescu et al ⁹ (2014)	Alginate impression was taken followed by pouring of the master cast. Photographs (front and side view) with a Nikon D5100 professional camera were captured and a database with 824 pictures was established.	Female Subjects demonstrated sharp tips w.r.t Lingual apex. On the contrary, male subjects presented with septate tips w.r.t lingual apex. The presence of scrotal and geographic tongue was more prevalent in female subjects as compared to male subjects.
2.	Amit Bade et al ²⁰ (2015)	Dual tree complex wavelet transform (DT-CWT) was used to extract unique features of tongue (size, shape, textures)	Better denoising of an image in a real-time environment.
3.	T.Radhika et al ² (2016)	Verification was done by capturing digital photographs of the tongue and matching it with the database. The shape of the tongue was obtained by joining the three reference points.	Length and width: Males > Females

4.	T.Radhika et al ¹⁶ (2017)	Pilot study: Visual inspection of the dorsal surface of the tongue followed by digital photographs. This was followed by Alginate impression and pouring of the master cast. Two observers separately analyzed the photographs and the casts and examined the intricate details of the surface morphology including shape, presence or absence of fissures and its pattern of distribution. The shape of the tongue was determined by three reference points.	The dorsum of the tongue was characterized by the presence of central fissure. In males, there were multiple vertical, shallow fissures while in females, there was a single, Vertical deep fissure.
----	--------------------------------------	---	--

CONCLUSION AND FUTURE

The human tongue being well-encased in the mouth cannot be easily forged, thus, acquiring an edge over the other biometrics in terms of its uniqueness. This can be considered as a powerful biometric tool to deal with the increasing identity fraud. The privacy of the users can be protected as the explicit features of the tongue are difficult to be reverse-engineered. Tongue-prints of the human tongue qualify as a reliable new member of the biometrics family⁸ because of its genetic independence, stability over time and physical protection from the external environment⁵ allowing it to be used for forensic identification purposes as an adjunct to rugoscopy and cheiloscopy.¹⁰

It is mandatory to create a database to explore the use of tongue prints in forensic dentistry. Dentists can assist in building the database by routinely collecting images of the tongue and preparing a cast of every patient who visits the clinic. This data should be meticulously stored along with other dental records.^{15,21} If the tongue recognition system for authentication is implemented practically with the use of sensors, then it would be a stepping stone in personal identification and authorization process using security.²⁰

Financial support and sponsorship: Nil.

Conflicts of interest:

There are no conflicts of interest.

REFERENCES

- Reddy MV, Kiranmai R, Kumar NV. Tongue scanning as a biometric tool for improvising the security in identification. International Conference on Recent Trends in Engineering Science and Management 2017;114-118.
- Radhika T, Jeddy N, Nitthya S. Tongue prints: A novel biometric and potential forensic tool, J Forensic Dent Sci 2016 Sep-Dec; 8(3): 117–119.
- Divakar KP. Forensic Odontology: The New Dimension in Dental Analysis. International Journal of Biomedical Science 2017 Mar;13(1):1-5.
- Bhattacharyya D, Ranjan R, Alisherov F, Choi M. Biometric authentication: A review. Int J UE Serv Sci Technol. 2009;2:13–28.
- Abraham J, Binita G, Sandra EJ. A Morphological study of Tongue and its Role in Forensic Odontology. J Forensic Sci and Criminal Inves. 2018;7(5):1-5.
- Jung HS, Akita K, Kim JY. Spacing patterns on tongue surface-gustatory papilla. Int J Dev Biol 2004; 48(2-3):157-61.
- Zhang B, Zhang H. Significant geometry features in tongue image analysis. Evidence-Based Complementary and Alternative Medicine 2015;2015:897580.
- Diwakar M, Maharshi M. An Extraction and Recognition of Tongue-Print Images for Biometrics Authentication System. International Journal of Computer Applications 2013;61(3): 36-42.
- Stefanescu CL, Popa MF, Candea LS. Preliminary study on the tongue-based forensic identification. Rom J Leg Med. 2014; 22:263–6.
- Vijay P, Sharma S, Chandra S, Pardhe N, Singh P, Srivastava Y. A study on Evaluation of various tongue patterns in North Indian population and a working classification system for these tongue print patterns. Int Healthc Res J. 2019;3(2):76-79.
- Liu Z, Zhang D, Tang QL. A tongue-print image database for recognition. Mach Learn Cybern. 2007; 4:2235–8.
- Markandey V, Chopra J. Tongue print Analysis for colored images using MSE for Person Identification. Int J Technical Innovation in Modern Engineering & Science 2017;3(4):165-170.
- Yan Z, Wang K, Li N. Computerized feature quantification of sublingual veins from color sublingual images. Comput

- Methods Programs Biomed. 2009;93:192–205.
14. Ménard L, Aubin J, Thibeault M, Richard G. Measuring tongue shapes and positions with ultrasound imaging: A validation experiment using an articulatory model. *Folia PhoniatrLogop.* 2012;64:64–72.
 15. Sreepradha C, Vaishali MR, David MP. Tongue replica for personal identification: A digital photographic study. *J Indian Academy of Oral Medicine and Radiology* 2019;31(1):57-61
 16. Jeddy N, Radhika T, Nithya S. Tongue prints in biometric authentication: A pilot study. *J Oral MaxillofacPathol.* 2017 Jan-Apr; 21(1): 176–179.
 17. Abranalingam, Desai D, Shubhalakshmi, Singh C. Comparison of Lip prints, Rugae Pattern and Tongue Prints among Karnataka, Kerala and Tami Nadu Population – A Short Study. *Int J Innovative Sci and Res Technology* 2019;4(7):1182-1187.
 18. Zhang D, Liu Z, Yan J, Shi P. Tongue-Print: A Novel Biometrics Pattern. *International Conference on Biometrics* 2007;4642:1174–1183.
 19. Markandey V, Chopra J. Tongue as a Biometrics Entity. *International journal of applied science engineering and management* 2012;3(5):1-6.
 20. Bade A, Chavan K, Admane P, Komatwar R. Tongue Recognition system for authentication. *International Journal for Research in Applied Science & Engineering Technology* 2015;3(3):76-80.
 21. Jeddy N, Ravi S, Radhika T. Current trends in forensic odontology. *J Forensic Dent Sci.* 2017;9(3):115-119.

How to cite this article: Godbole M, Narang B, Palaskar S et.al. Tongue scanning as a biometric tool: a review article. *Int J Health Sci Res.* 2020; 10(4):108-114.
