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A COMPARATIVE STUDY OF FACE BIOMETRICS AMONG BRAHMIN AND VAISHYA MALES OF LUCKNOW DISTRICT (UTTAR PRADESH)

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ABSTRACT

Biometrics refers to a particular class of identification technologies which use an individual's unique biological traits to determine one's identity. These days, the biometrics of the face is a very interesting issue in biometric identification systems. Faces have long been used as a means of human identification in the forensic field. Its reliability increases when we concentrate on specific population due to uniqueness of its gene pool. This article is based on the comparative analysis of face biometrics of Brahmin and Vaishya communities of Lucknow District. The data for the study was obtained from 200 male subjects (100 Brahmins males and 100 Vaishyas). Thirteen measurements were taken using seventeen selected landmarks and 21 indices were calculated from the frontal face images of each individual. A t-test revealed, significant ethnic differences ($p<0.05$) between Brahmin and Vaishya males for nasal breadth (P=0.00), upper lip height (P=0.00), binocular nasal width index (P=0.00), nose-facial width index (P=0.01), nasal width-facial index (P=0.01), mouth height index (P=0.04), lip index (P=0.01), and vermillion height index (P=0.01). The result indicates that this method is useful in recognizing faces.

Keywords: Face Recognition, Biometrics, Brahmins, Vaishyas, Males

INTRODUCTION

In the present day, traditional identification and verification system has come under much scrutiny. This has been largely due to large frauds and attention surrounding terrorist activities. To meet the modern day needs of identification, a number of more robust methods have been researched. These methods, which aim to uniquely identify individuals using information about a person's physical make up, are known as biometrics (Jain *et al.,* 2004).

Anthropology plays an important role in seeing connections with historical and cultural development of biometrics in the world. Biometrics has been a useful instrument to forensic anthropologists. It is based on measurable

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characteristics specific to a person. PINs and passwords are not easy to remember and can be stolen or guessed; cards, tokens, keys and others can be misplaced or forgotten; magnetic cards may become corrupted and uncertain. However, an individual's biological traits cannot be misplaced, stolen or forgotten. Thus, biometric systems are becoming important means of identification. It is therefore important to develop scientific methods of identification by studying various morphological and metrical approaches among different populations.

Fundamentals of Biometrics

The term biometrics has its origin from the Greek words bios "life" and metric "measure", which directly translates into'life measurement'. Biometrics is the most powerful technology sector that refers to an individual class of identification technology. These technologies use an individual's unique biological traits to establish one's identity. Simply stated, biometrics is a person's identification based on his/her morphological, physiological or behavioural characteristics. Every human being's physiological or behavioural characteristic can be used as a biometrics characteristic as long as it is universal, exclusive and permanent (Jain et al, 2004). Biometrics cover a large range of technologies that can be used to identity and verify human beings by measuring and analyzing human characteristics. Most of the systems need personal reliable recognition system to prove or determine the identity of an individual who requires a particular service (Sumathi and Malini et al., 2011). Biometrics can be arranged into two classes namely, Physiological Biometrics (including face, fingerprint, hand geometry, iris, ear, retina, DNA and palm print) and behavioral biometrics (including signature, keystroke, speech recognition and gait).

Modules of biometric systems: A simple biometrics system consists of following 6 basic modules:

- **Portal** is meant to protect some assets. A model of a portal is the gate at an entry of a building. If the user has been successfully authenticated and is authorized to access an object then access is granted**.**
- **Central controlling unit** receives the authentication request, controls the biometrics authentication development and returns the outcome of user authentication.
- **Input device** is used for biometrics data acquisition. During the acquisition technique user's liveness and value of the model may be confirmed.
- **Feature extraction module processes** the biometrics records. The output of the module is a locate of extracted features appropriate for the matching algorithm. During the feature extraction process the module may also evaluate quality of the input biometrics data.
- **Storage of biometrics templates** is a kind of database. Biometrics

templates can also be stored on a user-held medium (e.g., smartcard). In that case a link between the user and his biometrics template must exist (e.g., in the form of an attribute certificate).

- **Matching algorithm** compares the current biometrics features with the stored template. The desired protection threshold level may be a parameter of the matching method. In this will be yes/no reply (Single and Srivastava, 2011).

Face Biometrics: The main aim of biometry is to make systems that can identify people from some recognizable characteristics such as their face, fingerprints, iris, etc. Identification of humans by the unique characteristics of their face is called facial recognition. With the globalization of the world, the requirement of identification of individual has increased and has become a necessity of the current age. Face recognition is a challenging and an important biometric technique of identification. Modern face recognition has achieved an identification rate of higher than 90% for larger databases with well-controlled lighting and pose situations (Fromherz et al., 1997).

In the past, facial recognition in the forensic context referred to the process of using eye-witnesses to identify a suspect from either a physical or photo line-up. In today's terminology, facial recognition is the use of an automated system to determine matches to a probe image from a gallery of images, a one-to-many search, or to verify the identity of an individual, a one-to-one check. The one-to-many process can propose suspects to be investigated or can generate candidate lists to be shown to eyewitnesses. This differs from forensic facial identification, which is a manual process where an expert performs a photographic comparison focusing on the face of an individual.

A new approach was introduced in year 2012 in which the facial features from training images are extracted, then ratios of length, width, and area are calculated and stored as features for individual images. This uniqueness of face eventually helps us to identify a person and differentiate it from another face. Face has its individual form, dimensions and features which can be evaluated morphologically as well as metrically (Roelofse et al., 2008). Among the various types of biometrics, face recognition system is the most accurate. Facial recognition analyzes the characteristics of a person's face images input through a digital camera. Each face has several, distinguishable landmarks, the varied peaks and valleys that make up facial features (Newman et al., 2009). Several of these features measured by the Facial Recognition Technology are: space between the eyes, nose length, breadth of the nose, length of the jaw line, region surrounding cheek bones, sides of mouth, etc. These measurements are kept in a database and used as a comparison when a user appears before the camera (Manikpuri et al., 2011). It is projected that biometric facial recognition system will quickly overtake fingerprint biometrics as the most famous appearance of user authentication. With the extensive utilization of digital cameras, smart phones and CCTVs, face images can be simply produced all day. In accumulation,

these images can be rapidly transmitted and shared through highly developed internet (Ho and Li, 2015).

Face Recognition Methods: In the beginning of the 1970's, face recognition was treated as 2D pattern recognition. (Goldstein, et al., 1971). The distances between main points were used to recognize known faces, e.g., measuring the space between the eyes or other important points or measuring various angles of facial components. A number of algorithms have been proposed for face recognition. Such algorithms can be divided into two categories, namely appearance-based and feature-based.

(a) Appearance-based method: This method uses the whole face area as the input to the face recognition system. This system usually operate on 2D images, using the raw image data to make comparisons with other face images. It has received significant attention from a wide range of research areas such as biometrics, pattern recognition. In this method, there are two implied categorizations, viz., holistic and hybrid approaches (Nefian and Hayes et al.,1998). In the *holistic method*, face recognition utilizes global information from faces to perform face recognition and the overall information from faces is basically represented by a small number of features which are straightforwardly derived from the pixel information of face images. (Gandhe, and Keskar,et al., 2007). These small numbers of features distinctly capture the difference among faces of different persons and therefore are used to uniquely identify persons. Among appearance-based holistic approaches, Eigenfaces and Fisherfaces have proved to be effective in experiments with large databases (Vishwakarma and Gupta et al., 2010). *Hybrid face* recognition systems use a combination of both holistic and feature extraction methods. Generally, 3D Images are used in hybrid methods. The image of an individual's face is caught in 3D, allowing the method to note the bends of the eye sockets, for example, or the forms of the chin, etc. Even a face in profile would serve because the method uses depth, and an axis of measurement, which provides it sufficient information to construct a complete face.

The 3D method typically proceeds thus: Detection, Position, Measurement, Representation and Matching. Detection - Capturing a face either a scanning a photograph or photographing a individual's face in actual time. Location – Determining the position, angle and size of the head. Measurement - Assigning measurements to every bend of the face to build a template with definite focus on the external side of the eye, the inside of the eye and the angle of the nose. Representation - changing the template into a code - a statistical representation of the face and Matching - Comparing the expected data with faces in the existing database (Parmar and Mehta, 2013).

(b) Feature Based Method: The facial features of human being have played a significant task in the recognition of persons for long time. After performing anthropometric measurement on several frontal face images

taken from various human subjects, an anthropometric model of the human face is build that can be used to locate the most important facial feature areas from face images (Sohail and Bhattacharya, 2008). Feature-based face recognition involves taking measurements of the individual constituents and contours of the face (Craw et al.,1992). Feature-based face recognition uses a priori information of faces to select a number of features to exclusively identify individuals. First the input image is processed to identify and extract unique facial features, including eyes, nose, mouth, lips and chin, etc., which have played a significant role in the recognition of individuals, which are selected from face images, and then compute the geometric relationships properties among those facial points, thus tumbling the input facial image to a vector of geometric features and relations such as areas, distances between the features are selected as the descriptors of faces for recognition (Ivancevic *et al.*, 2003). Standard statistical pattern recognition techniques are then employed to match faces using these measurements. The main advantage obtained by the featured-based techniques is that since the extraction of the feature points precedes the analysis done for matching the image to that of an identified individual, such techniques are relatively strong to locate variations in the input image. It is appreciably different from the feature-based systems (Beham and Roomi, 2013). This method can detect facial features very well. It has been a popular method in biometric recognition area (Cannon *et al.,*1986).

Thus, holistic approaches represent global information of faces; the disadvantage of this approach is the variances captured may not be relevant features of the face. One advantage of using feature-based approaches is that they attempt to precisely capture relevant features from face images. Depending on the exclusive shaping of each person's face, it has been a popular method in biometric recognition region.

(c) Geometric Feature Based Method: In many biometrics applications, features are also extracted manually. The goal is to guarantee precise identification of the features. In facial recognition, geometric properties and relations such as areas, distances and angles between the features are selected as the descriptors of faces for recognition. Therefore, the geometric attributes provide reimbursements in data reduction and less sensitivity to variations in lighting, pose, and expressions. (Ivancevic et al., 2003). The features are extracted by using relative locations and sizes of the essential components face such as nose, eyes, mouth and other essential component face. Therefore, the geometrical relationship existing in these is computed. Then the standard pattern recognition methods are used to compare faces. (Parmar and Mehta, 2013). Geometric features can be derived from either the frontal view or the profile of a face. Geometric, which illustrates at unique features or photometric and

statistical approach that refine an image into values and comparing the values with template to remove variances. The geometric face recognition algorithms identify faces extracting features from a subject's face. Algorithm analyzes the frontal view features, relative position, size, shape of the features, like eyes, nose, cheekbones, and jaw and angles comparing these features with other images (Samal and Starovoitov, 1998).

Photo-anthropometry: Various studies have shown that the personal identification process can also be done by using anatomical landmarks and measurements or proportions obtained using landmarks from the photograph evidence. This technique traces its roots to traditional anthropometric methods. In face anthropometry, the quantification measurements are taken from photographs; it is called photo-anthropometry. This form of identification can be termed as 'Facial Image Identification' or 'Photo-anthropometry', which is based on the spatial measurements of facial features as well as distance between facial landmarks (Alspaugh, 2004). Photo anthropometry uses predetermined facial landmarks for measurement of the face from an image; it is a metric based facial image comparison. Here the distances and angles between anatomical landmarks in the images are calculated and compared and analyzed. Photo-anthropometry is now an acceptable tool in the identification with a manual technique (Iscan and Loth et al., 2000) In the present research to overall the manual method for identification.

The present study was conducted to apply the fundamental principles of face biometric for identification of Brahmins and Vaishyas population inhabiting Lucknow District. The study was also aimed to investigate interpopulation variation between Brahmins and Vaishyas community based on face biometric.

MATERIALS AND METHODS

Data for the present study were collected from various colleges and university of Lucknow Region. For this research work, face biometrics of 200 male individuals aged between 18-40 years of two endogamous caste groups, i.e., Brahmins (n=100) and Vaishyas (n=100), of Lucknow District were collected through photographs. The subjects were chosen by purposive and snow ball sampling. Before taking the photographs of the subjects, general information, including name, age, sex, community, caste, subcaste, domicile and address, of each subject was recorded (the information was cross-checked from the Identity card or Aadhar card) .

Data for the present study were selected from various colleges and University for the younger age groups in different areas of Lucknow Region.

Structure of Face Biometric system has four main features: Photography, Image Preprocessing, Normalization and Face Photometric Measurements (Brunelli and Poggio et al., 1993).

Photography: The frontal face photographs of 200 subjects were taken with a Sony Lens G Cyber Shot 20x optical zoom digital camera under similar lighting conditions, with no illumination changes, using a tripod. Setting of the camera was same throughout the collection of photographs. The camera was setup on a tripod at same height (of 105 cm). Each subject was made to sit comfortably on the stool with back straight and head positioned in eye-ear plane. Frontal face photographs of all the subjects were taken from an angle perpendicular to the head with a fixed distance of 2 feet between face and the camera. The White balance of camera was set at Fine, Continuous at Single, Image adjustment at Normal, Lens at Normal, Focus at AF area mode (Auto), Aperture at 10.3, Shutter speed at 0.25 seconds, and Zoom at Maximum optical. The photographs were saved in JPEG format and uploaded directly to the software (Adobe Photoshop CS3), with 300 dpi resolution.

Image Preprocessing: The photographic records were transferred to the computer with the help of Adobe Photoshop CS3 software that was used for image preprocessing. Face images were cropped manually from the side face image of a person. Since the sizes of the cropped face images were different, these were resized. In order to find same number of features from each frontal face image, resizing the images to a unique fixed size of 5x7 inches (1500 x 2100 pixel) was carried out. Coloured image were converted to gray scale image.

Normalization: The face needs to be normalized. To normalize an image, the key facial landmarks must be located accurately, i.e., the image must be standardized in terms of size, pose, illumination, etc. Light does not impact the normalization process. (Ramchandra and Kumar, 2013).The photograph of the frontal face was placed on a development easel and landmarks, such as zygion, sublabiale, gnathion, ectocanthion, stomion, labrale superius, labrale inferius, endocanthion, cheilion, nasion, alare, and subnasale, were then detected. These landmarks are used to normalize the image and to initialize the method that localizes the facial components (eyes, cheeks, nose, and mouth, chin) and precisely extracts 17 facial landmarks, from the frontal images of a face, which are shown in Figure-1and Figure-2. These measurements have been used to distinguish individuals.

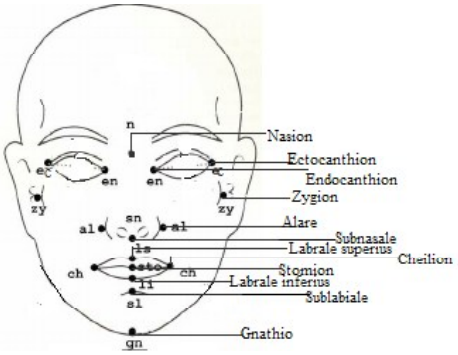

Figure-1: The location of some of the anatomical landmarks used in facial photometric

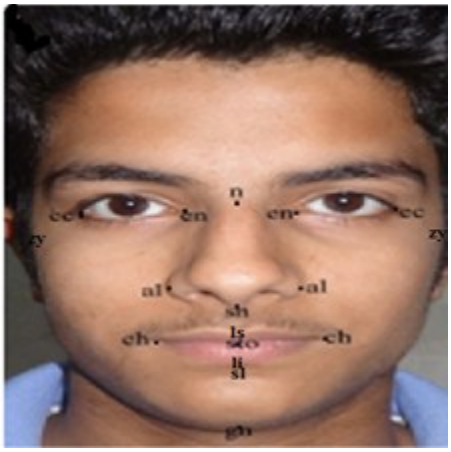

Figure-2. The 17 facial landmarks of frontal face used in face biometrics measurements.

Face photometric measurements: Feature based methods use the facial feature measures, such as distance between eyes, ratio of distance between eyes and nose, mouth, and chin, etc. Features may be generated by segments, perimeters, angles and areas of some figures formed by the landmarks (Goldstein, *et al.,* 1971; Kaya *et al.,*1971-). The facial pictures were carefully scaled using the distances between landmarks in the vertical plane and in the horizontal plane. These were then equally carefully aligned and lines drawn through as many landmarks as possible. Photo-anthropometry is based on quantitative analysis on measurements of the distances and angles between anatomical facial landmarks and the invention of indices based on them. The measurements were taken on the photographs with sliding caliper and then the possible proportions were worked out from these measurements taken on photograph. 13 measurements between 17 landmarks were selected manually and 21 indices were calculated and 3 angles were taken from frontal photograph of each subject. These measurements are used for personal identification, which were illustrated in Figure-3.

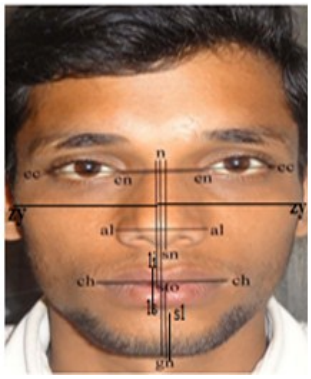

Figure-: Frontal face photograph used in 13 photo-anthropometric measurements

Indices were calculated as follows: Index = Smaller dimension / Large dimension ×100

In this study, the data entry and analysis were done by using SPSS version 20 to obtain the following statistical tests: arithmetic mean ($\overline{X}$), standard deviation (ó) and students t-test.

RESULTS

Uniqueness in Face Biometrics of Brahmins and Vaishyas

The gene pool of a population presents the characteristic of the population that determine its unique feature. This uniqueness is the basis on which an individual may be assigned a group with which similarity is observed. The characteristics related to biometrics of the both communities are elucidated here.

Table-1 and Table-2 display the phenotypic variables of Vaishya and Brahmin males of Lucknow Region. The descriptions of both communities are hereby interpreted comparatively as distinct phenotypic variables with respect to ethnic variance in different face measurements. Independent t-test has been employed to find out variance in facial measurements as well as various indices calculated from different facial measurements.

Table-1: Ethnic variance in different face measurements among Brahmin and Vaishya males of Lucknow Region

Measurements	Brahmin Males		Vaishya Males		*t*-Value	*p* value
	Mean(cm)	SD(cm)	Mean (cm)	SD(cm)		
Morphological facial height (n-gn)	10.19	0.40	10.20	0.45	-0.18	0.85
Bizygomatic Breadth (zy-zy)	11.51	0.44	11.54	0.42	-0.48	0.62
Interocular breadth (en-en)	2.86	0.25	2.92	0.27	-1.62	0.10
Binocular breadth (ec-ec)	8.37	0.37	8.36	0.41	0.01	0.98
Nasal breadth (al-al)	3.73	0.24	3.83	0.27	-2.73	0.00**
Physiognomic superior facial length (n-sto)	6.35	0.36	6.38	0.43	-0.54	0.58
Height of the lower face (sn-gn)	5.71	0.39	5.64	0.50	1.06	0.28
Nasal length	(n-sn)	4.49	0.37	4.55	0.39	-1.07
0.28						
Mouth breadth (ch-ch)	4.75	0.38	4.82	0.33	-1.36	0.17
Height of mucous lips (ls-li)	1.54	0.31	1.46	0.30	1.90	0.06
Upper lip height (ls-sto)	0.52	0.18	0.45	0.14	2.96	0.00**
Lower lip height (sto-li)	1.03	0.20	1.00	0.21	0.89	0.37
Chin length (sl-gn)	2.32	0.28	2.34	0.37	-0.48	0.62

*Significant (p<0.05); **Highly Significant (p<0.001)

Table-1, illustrates the means and standard deviations of various facial measurements of Brahmin and Vaishya males of Lucknow region. The values of t-test indicate that the ethnic differences were significant only for a couple of

measurements and for majority of the facial measurements the differences were not significant (P<0.05). As is clear from Table-1, the ethnic differences were found to be significant (p<0.05) for nasal breadth and upper lip height.

Table-2: Independent 't' Test for variance Indices calculated from different facial measurements among Brahmin and Vaishya males of Lucknow Region for Ethnic differences

S.No.	Indices	Brahmin Males		Vaishya Males		t-value of p	value
		Mean	SD	Mean	SD		
1	FI	88.43	4.69	88.52	5.18	0.09	0.92
2	ICI	34.16	2.64	34.88	2.45	-1.99	0.08
3	ICNWI	76.74	7.46	76.37	7.41	0.35	0.72
4	BNWI	44.67	2.75	45.88	3.25	-2.82	0.00**
5	ICWFHI	28.09	2.60	28.65	2.65	-1.51	0.13
6	BWFHI	82.21	3.99	82.13	4.65	0.13	0.89
7	UFHBWI	75.95	4.22	76.41	5.97	-0.62	0.53
8	UFFHI	62.33	2.76	62.57	3.59	-0.51	0.60
9	LFFHI	56.10	3.12	55.33	3.96	1.50	0.13
10	NI	83.49	7.16	84.56	9.10	-0.92	0.35
11	NFI	44.14	3.33	44.70	3.49	-1.16	0.24
12	NFWI	32.46	2.02	33.25	2.35	-2.55	0.01*
13	NMWI	78.93	5.91	79.77	6.31	-0.97	0.33
14	NWFI	36.70	2.44	37.65	3.06	-2.43	0.01*
15	MHI	15.11	2.84	14.29	2.86	2.03	0.04*
16	MWI	56.84	4.74	57.67	3.86	-1.35	0.17
17	MFWI	41.33	3.10	41.81	3.03	-1.10	0.27
18	LI	32.51	6.24	30.29	6.18	2.52	0.01*
19	VHI	51.17	15.00	46.10	13.25	2.53	0.01*
20	CHI	22.77	2.73	22.97	3.52	-0.44	0.65
21	U FI	55.22	3.78	55.39	4.46	-0.28	0.77

*Significant (p<0.05); **Highly Significant (p<0.001)

Table 2 shows the means and standard deviations of different face indices of the Brahmin and Vaishya males of Lucknow region. The results of t-test suggest that ethnic differences were significant (p<0.05) for a few facial indices only. For a majority of the indices, the differences were non-significant (p<0.05). As can be seen in Table-2, among Brahmin and Vaishya males, the ethnic differences in facial proportion indices were significant (p<0.05) for binocular nasal width index, nose facial width index, nose width facial index, mouth height index, lip index and vermillion height index.

CONCLUSIONS

Among all the biometric techniques, face recognition approach possesses one great advantage, which is user-friendliness (non-intrusiveness). Facial images

are probably the most common biometric characteristic used by humans to make an identification. However, the increase in the use of photographs on individual identification credentials, such as driving licences, credit cards, security passes passport, etc., has also led to increasing cases of falsification of genuine documents for the purpose of criminal activities. Comparison of indices of the facial measurements taken on a photograph of an individual have the potential be used for personal identification purposes. Moreover, photographs can be used as valuable physical evidence when compared with known photographs of a suspect. In this work, unique as well as common facial characteristics of Brahmins and Vaishya communities of Lucknow region were identified. With respect to facial proportion indices, the ethnic differences were significant ($p<0.05$) for nasal breadth *and* upper lip height. Likewise, the ethnic differences between Brahmin and Vaishya males were significant for binocular nasal width index, nose-facial width index, nasal width-facial index, mouth height index, lip index and vermillion height index. Thus, facial measurements and facial proportion indices have a potential in developing facial recognition tools.

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