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Implications of Facial Photogrammetry and Photomorphology: A Review

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Abstract

Physical features ofindividuals are very specific and theface of a person varies the most from individual to individual which plays an imperative role in personal identification and recognition. We recognize a person by facial appearance that is why facial photographs are added as a mark of personal identification on passports, identity cards, driving licence, admission forms, employment registration/application form etc. The factors like age, sex, race, ethnicity and food habits highly affect the facial features therefore can be used for recognition purposes. A range of studies have been undertaken by many scientists all over the globe using either photomorphological characters or photogrammetrical means which show a great implication in identification of a person. Such studies are of great help in the field of Physical Anthropologists, Forensic Scientists, Human Biologists and Cosmetic Surgeons.

Keywords: *Anthropometry, personal identification, facial photographs,photogrammetry, photomorphology*

Introduction

Method of taking measurements between definite surface points called landmarks from photographs is known as Photogrammetry. There are several applications of these measurements which help in identification of race, gender, ethnicity and age also. In past a lot of studies has been made which clearly shows its implications in different fields. Present paper focuses on different extent of photogrammetricaland photomorphologicalstudies on facial photographs. There are various landmarks present on facial photographs which are usually considered for photogrammetry. Following somatometric landmarks can be taken in account for identification purpose.(See table 1 and fig 1)

Table 1: Different landmarks and their definitions

S.No	Landmark	Abbr.	Definition
1	**Alare**	**al**	The lateral most point on the wings of nose.
2	**Cheilion**	**ch**	Outer corners of the mouth or the points where lateral margins of upper and lower lips meet.
3	**Ectocanthion**	**ex**	Outer corners of the eyes or the outer points where upper and lower lid margins meet.
4	**Endocanthion**	**en**	Inner corners of the eyes or the inner points where upper and lower lid margins meet
5	**Glabella**	**g**	The forward most point between the two eyebrows on the midsagittal plane.
6	**Gnathion**	**gn**	The lowest median point on the lower border of chin
7	**Gonion**	**go**	The lateral most point on the angle of the jaw.
8	**Labrale inferius**	**li**	The median point in the lower boundary of mucous surface of lower lip.
9	**Labrale superius**	**ls**	The point where the mid-sagittal plane crosses the tangent drawn across the upper curves of boundary of the mucous s of the upper lip.
10	**Nasion**	**n**	The point where the inter-nasal suture meets the frontonasal suture in the mid-sagittal plane
11	**Prosthion**	**pr**	The lowest point on the gum between the two medial incisors. It somewhat corresponds to the lowest point of the integumentary upper lip on the midsagittal plane
12	**Pronasale**	**prn**	The forward most projecting point of the nose
13	**Subnasale**	**sn**	The point where nasal septum meets the surface of the upper lip on the mid-sagittal plane
14	**Stomion**	**sto**	Median point of the oral slit when mouth is closed naturally
15	**Trichion**	**tr**	The point where the anterior line of hair on the forehead is cut by the mid-sagittal plane
16	**Zygion**	**zy**	The lateral most point on the zygomatic arch. The point has to be explored

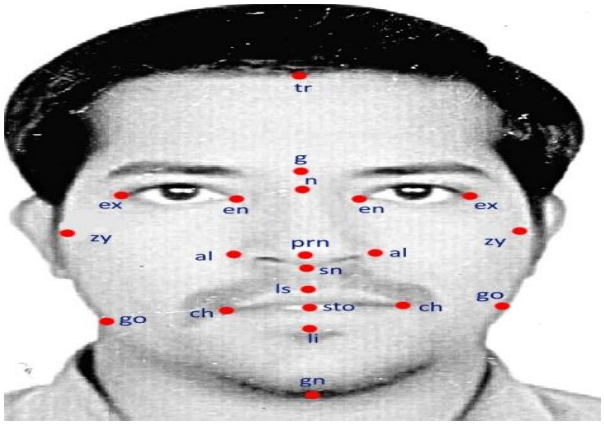

Figure 1 Somatometric landmarks

On the basis of these somatometric Landmarks following indices are calculated (See table 2)

Table 2: Different indices of facial region

S.No	Index	Formula
1	**Morphological facial index (MFI)**	(n-gn) X 100/ (zy-zy)
2	**Physiognomic facial index (PFI)**	(tr-gn) X 100/ (zy-zy)
3	**Upper facial index (UFI)**	(n-sto) X 100/ (tr-gn)
4	**Inter orbito jugular index (IOJI)**	(ex-ex) X 100/ (zy-zy)
5	**Interorbital breadth index (IOBI)**	(en-en) X 100/ (zy-zy)
6	**Jugo mandibular index**	**(go-go)** X 100/(zy-zy)
7	**Nasal index (NI)**	(al-al) X 100/ (n-sn)
8	**Nasal elevation index**	**(sn-prn)** X 100/ (al-al)
9	**Face lip index (FLI)**	(ls-li) X 100/ (n-gn)
10	**Lip index (LI)**	(ls-li) X 100/ (ch-ch)

Following morphological features of facial region are usually taken in account for identification purpose (fig 2 to fig 4):

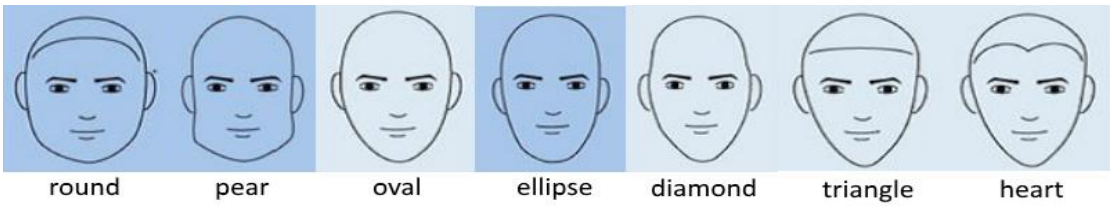

Figure 2: Different shapes of face

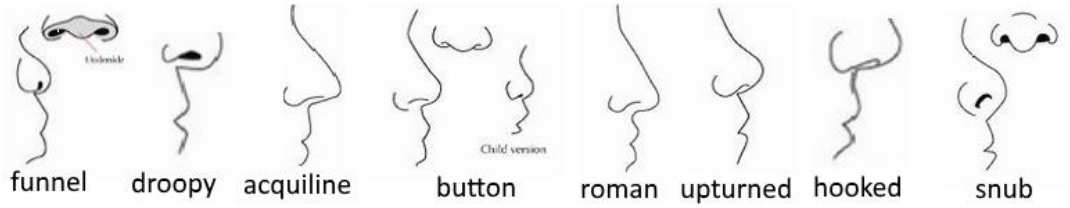

Figure 3: Different shapes of nose

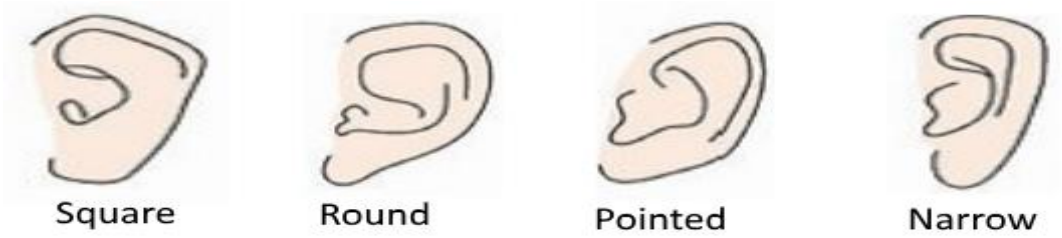

Figure 4: Different shapes of Ear

(Images Source: https://design.tutsplus.com/tutorials/human-anatomy-fundamentals-advanced-facial-features--cms-20683)

The study of face for forensic purposes uses analysis techniques such as metrical analysis, morphological analysis and superimposition. Metrical analysis involves the measurements between various facial landmarks and their proportions known as indices. Morphological analysis involves the study of form, size shape of facial features. It includes overall facial outline, face shape, shape of ears, eyes, nose, lips, chin etc.Morphology, from the Greek and meaning "study of shape", and Photomorphological means the Study of shape from photographs.The importance of morphological features is surely indispensable as we recognize a person from morphological features. This is true for facial photographs also.

❖ **Personal identification:** Facial landmarks and facial indices can give a perfect identity of a person.Porter and Doran (2000) described a photographic technique that allows accurate anatomical measurement and tracing of facial features which allows direct physical comparison of facial photographs. In this study author(s) examined and compared enlarged facial photographs of original ID documents and arrest photographs.Dibeklio ̆glu et al (2012) described a statistical method for automatic facial-landmark localization. Landmarking relied on a parsimonious mixture model of Gabor wavelet features, computed in coarse-to-fine fashion and complemented with a shape prior. Assessment of accuracy and the robustness of the proposed approach in extensive cross-database conditions conducted on four face data sets (Face Recognition

Grand Challenge, Cohn–Kanade, Bosphorus, and BioID). This method has 99.33% accuracy on the Bosphorus database and 97.62% accuracy on the BioID database on the average. Campomanes-Álvarez et al (2014) studied the dispersion assessment of location of landmarks using facial photographs. Also it was studied how precision of locating landmarks change with landmark type. In this work, statistical evaluation of the inter- and intra-observer dispersions related to the facial landmark identification on photographs was studied. In the inter-observer experiment, a set of 18 facial landmarks was provided to 39 operators. Zappa and Mazzoleni (2010) in a study evaluated the reliability of face identity recognition technology by developing an algorithm of face recognition based only on the 3D localization of some significant points of the face and applied on a 51 people database. The result showed recognition percentage greater than 90%.Gupta et al (2010) presented a novel anthropometric 3D face recognition algorithm based on systematically selected set of discriminatory structural characteristics of human face. A novel technique was proposed for automatic detection of 10 anthropometric facial fiducial points along with a complete automated face detection algorithm.

❖ **Aging:** The average change in facial indices can be helpful in judging the age of a person to some extent, though intricate studies need to be undertaken on different races, ethnic groups. Although there are many influencing factors which affects such studies like background of a person, genetic factors, eating habits, habitat or any diseaseetc. Studies show that there is a marked difference in the morphological features of babies, children, adolescents and old age which is helpful in ascertaining the age of a person. Gender based studies has also been conducted regarding aging in different age group.Bishara et al (1995) evaluated the changes in facial dimensions with age and also provided normative standards that can be used for comparative purposes. This study was done on serial facial photographs (frontal and lateral) obtained from 20 subjects. Sforza et al (2009) studied Age and sex related changes in normal human ear. 843 healthy white Italians aged 4 – 73 years participated in the study. Three dimensional coordinates of several soft tissue landmarks were obtained using computerized electromagnetic digitizer. All ear dimensions were found larger in men as compared to women. In older individuals ear dimensions had larger value as compared to younger individuals. The ear width to length ratio showed sex related differences. Sforza et al (2010) studied Age and sex related changes in normal human external nose. 859 healthy white Italians aged 4 – 73 years participated in the study. Three dimensional coordinates of several soft tissue landmarks were obtained using computerized electromagnetic digitizer. Sexual dimorphism was observed for external nose volume, linear measurements, and nasal width to height ratio. Age significantly influenced all measurements of nose. Sforza et al (2010) studied Age and sex related changes in soft tissue of the orbital region. 888 healthy white Italians aged 4 – 73 years participated in the study. Three dimensional coordinates of several soft

tissue landmarks were obtained using computerized electromagnetic digitizer. An increment of soft tissue orbital area was observed during aging. Sforza et al (2010) studied Age and sex related changes in lip morphology. 918 healthy white Italians aged 4 – 73 years participated in the study. Three dimensional coordinates of several soft tissue landmarks were obtained using computerized electromagnetic digitizer. Mouth width, width of philtrum, total lip length, lip volume, vermilion areas and heights of lower and total lips increased with age whereas the vermilion height to mouth width ratio decreased with age.

❖ **Ethnicity and Gender:** It is well known that the eyes, nose, mouth, even the shape of the face, all vary Immensely, and no two people except the twins have the same combination of the features Many studies have shown that there is marked variation in the average size of facial landmarks between male and female. Photogrammetrical studies have shown that we could establish a link between race and ethnicity on the basis of facial landmarks.Hosoi et al (2004) in their study proposed an ethnicity estimation system after experimenting with 1991 images.Lu and Jain (2004) presented Linear Discriminant Analysis based scheme to classify between Asian and non-Asian classes using face images of 263 subjects. Roelofse et al (2008) studied rare and common facial characteristics in a group of Bantu speaking South African men. In this study 200 male volunteers were selected and their facial photographs were obtained. Anibor and Okumagba (2010) studied aesthetic angles in 100 subjects both male and female aging 18 to 25 years belonging to Ibo ethnic group of Nigeria. Tin and Sein (2011) in a study classified 250 face images into two different sets based on ethnicity using Principal Component Analysis based scheme. A face image data set was collected from the internet and divided into a training dataset and a test dataset. Using face detector and face alignment tool, those faces were automatically cropped and normalized in grey level and geometry, and each face was labeled with an age value estimated by human subjectively. The dataset was separated into two race groups, Myanmar and Non-Myanmar. Khan et al (2012) in a pilot study investigated to obtain, average parameters that define the soft tissue facial profile of the subjects belonging to Deccan ethnic region. In this study faces of 40 young adults were studied with standardized photography and measurements and the data were collated to determine averages for the Deccan region ethnic subset. Taka et al (2012) conducted anthropometric study of Nasal Index in the Kosovo Albanian population. A total of 204 subjects of 18-25 years old were chosen for the study (101males and 103 females). Measurements were done by standard methods provided by Martin and Saller, 1975.Shrestha et al (2009) conducted a study of craniofacial anthropometric measurements in Sunsari district of Nepal among Rai and Limbu community. In this study 444 subjects (210 males and 234 females) of 25-50 years old were chosen. Choe et al (2004) in a study assessed the difference in facial proportions of Korean American and North White

American females. Aesthetic facial features of Korean American women were also quantitatively described. A total of 82 Korean American persons participated in study. Heidari et al (2006) in a study evaluated the cephalic and prosopic indices of adult women in southeast of Iran. This study was performed on young women of 18-25 years old in two aborigines of Sistani and Baluchi of southeast of Iran. Umar et al (2006) in a study provided cranial indices values for Nigerians. The study was carried out with a total number of 409 students of University of Jos and surrounding schools in Nigeria. Jahanshahi et al (2008) conducted a study on 808 young males and females of 17 to 20 years of age from two different ethnic groups (Fars and Turkmans) of Northern Iran.Ngeow et al (2009) in a study provided craniofacial anthropometric norms of Malays. In this study 100 young adults with equal number of female and male subjects were selected for study. Data of 22 linear measurements were taken twice from 22 landmarks over six craniofacial regions. It was concluded after conducting the study that Malays shares many similar sizes of craniofacial measurements with the Singaporean Chinese.

- **Cosmetic Surgery:** Such studies are also very useful in medical profession where there is need to set right any facial disorder or to give an aesthetic look. One more implications ofPhotogrammetrical studies is in the field of Cosmetic surgery where the cognizance regarding the ethnicity is highly useful for the clinical surgeons. Tzou et al (2005) studied ethnic differences of facial movements between Europeans and Asians for free facial muscle transplant. Digitised three-dimensional video-analysis system was used in which 24 participants born in Taiwan and 24 participants born in Austria participated. It was concluded that Europeans have generally larger facial movements as compared to Asians in particular the mouth, nose and eyebrows region.

- **Facial reconstruction:** Forensic experts usually come across skull of a person in case of mass disaster, missing identity, massacre where they have to reconstruct whole face; photomorphological studies can be very significant in facial reconstruction.Miyasaka et al (1995) introduced a computer imaging system into facial reconstruction process. The system consisted image processing unit for skull morphometry and an image editing unit for composition of facial components on facial images. The system facilitated a rapid approach that allows user to easily generate a range of possible faces. Philips and Smuts (1996) in a study observed that the use of computerized tomography scanning method to measure soft tissue depth is much more accurate than the conventional needle probe method.Jones (2001) demonstrated a process for facial reconstruction from discovered skulls. In this study a computer aided technique was demonstrated along with an accurate 3D closing operator in practice on large data sets, automatic feature detection etc.

Conclusions

It can be concluded that the facial photomorphologicaland Photogrammetrical studies can be used as a tool for demographic studies, gender differentiation, and age estimation. Types of faces (different shape of face), nose shape and ear shapes vary from one region to another also variation shown in gender. Although there are many challenges due to factors like plastic surgery, beard, change in angle, aging, make up, change in weight and change in facial expressions which could be addressed by elaborative researches. The studies till now are reliable and provide a good platform for personal identification by means of gender, age, ethnicity etc. and also help in commencing the tasks of portrait parley, facial reconstruction and skull superimposition. Apart from forensics these studies shows great implications in the field of ergonomics, facial reconstructive surgeries, advanced biometric systems etc.

References

1. Anibor, E. and Okumagba, M. (2010). Photometric facial analysis of the Ibo ethnic group in Nigeria. Archives of applied science research, 2 (6), 219-222.
2. Bishara, S. E., Jorgensen, G. J., & Jakobsen, J. R. (1995). Changes in facial dimensions assessed from lateral and frontal photographs. Part I– Methodology. American Journal of Orthodontics and Dentofacial Orthopedics, 108(4), 389-393..
3. Campomanes-Álvarez, B. R., Ibáñez, O., Navarro, F., Alemán, I., Cordón, O., & Damas, S. (2015). Dispersion assessment in the location of facial landmarks on photographs. International journal of legal medicine, 129(1), 227-236.
4. Choe, K. S., Sclafani, A. P., Litner, J. A., Yu, G. P., & Romo, T. (2004). The Korean American woman's face: anthropometric measurements and quantitative analysis of facial aesthetics. Archives of facial plastic surgery, 244-252.
5. Das, B. M. (1985) Outline of physical anthropology, Kitab Mahal Publisher Allahabad 291-331.
6. Dibeklioğlu, H., Salah, A. A., & Gevers, T. (2012). A statistical method for 2-d facial landmarking. Image Processing, IEEE Transactions on, 21(2), 844-858.
7. Farkas, L. G., Katic, M. J., & Forrest, C. R. (2005). International anthropometric study of facial morphology in various ethnic groups/races. Journal of Craniofacial Surgery, 615-646.

8. Ghoddousi, H., Edler, R., Haers, P., Wertheim, D., & Greenhill, D. (2007). Comparison of three methods of facial measurement. International journal of oral and maxillofacial surgery, 36(3), 250-258.

9. Gupta, S., Markey, M. K., & Bovik, A. C. (2010). Anthropometric 3D face recognition. International journal of computer vision, 90(3), 331-349.

10. Heidari, Z., Mahmoudzadeh Sagheb, H. R., & Noori Mugahi, M. H. (2006). Morphological evaluation of head and face in 18-25 years old women in southeast of Iran. J. Med. Sci, 6(3), 400-404.

11. Hosoi, S., Takikawa, E., & Kawade, M. (2004, May). Ethnicity estimation with facial images. In Automatic Face and Gesture Recognition, 2004. Proceedings. Sixth IEEE International Conference on (pp. 195-200). IEEE.

12. Jahanshahi, M., Golalipour, M. J., & Heidari, K. (2008). The effect of ethnicity on facial anthropometry in Northern Iran. Singapore medical journal, 49(11), 940.

13. Jones, M. W. (2001, November). Facial Reconstruction Using Volumetric Data. In VMV, 135-150.

14. Kanwal, N.K. (2016): "Facial biometric: Versatile approach for personal identification", International Journal of Science & Engineering Development Research, Vol.1, Issue 8, 257 – 259.

15. Khan, N., Leela, V., & Annavarapu, G. (2012). A study of craniofacial anthropometrics in Hyderabad (Deccan)-and a review of literature. Journal of Medical & Allied Sciences, 2(2), 54.

16. Lu, X., & Jain, A. K. (2004, August). Ethnicity identification from face images. In Defense and Security (pp. 114-123). International Society for Optics and Photonics.

17. Miyasaka, S., Yoshino, M., Imaizumi, K., & Seta, S. (1995). The computer-aided facial reconstruction system. Forensic science international, 74(1), 155-165.

18. Ngeow, W. C., & Aljunid, S. T. (2009). Craniofacial anthropometric norms of Malaysian Indians. Indian journal of dental research, 20(3), 313.

19. Porter, G., & Doran, G. (2000). An anatomical and photographic technique for forensic facial identification. Forensic science international, 114(2), 97-105.

20. Rastogi, S., Shukla, B. R. K., Laboratory manual of physical anthropology (Anthropology and Osteology), Bharat book centre, 2003.

21. Roelofse, M. M., Steyn, M., & Becker, P. J. (2008). Photo identification: facial metrical and morphological features in South African males. Forensic science international, 177(2), 168-175.

22. Sen, T., A guide to anthropometry, the world press private limited, 1994.

23. Sforza, C., Grandi, G., Binelli, M., Dolci, C., De Menezes, M., & Ferrario, V. F. (2010). Age-and sex-related changes in three-dimensional lip morphology. Forensic science international, 200(1), 182-e1.

24. Sforza, C., Grandi, G., Binelli, M., Tommasi, D. G., Rosati, R., & Ferrario, V. F. (2009). Age-and sex-related changes in the normal human ear. Forensic Science International, 187(1), 110-e1.

25. Sforza, C., Grandi, G., Catti, F., Tommasi, D. G., Ugolini, A., & Ferrario, V. F. (2009). Age-and sex-related changes in the soft tissues of the orbital region. Forensic science international, 185(1), 115-e1.

26. Sforza, C., Grandi, G., De Menezes, M., Tartaglia, G. M., & Ferrario, V. F. (2011). Age-and sex-related changes in the normal human external nose. Forensic science international, 204(1), 205-e1.

27. Shrestha, O., Bhattacharya, S., Jha, N., Dhungel, S., Jha, C. B., Shrestha, S., & Shrestha, U. (2009). Cranio-facial anthropometric measurments among Rai and Limbu community of Sunsari District, Nepal. Nepal Medical College Journal, 3, 183-185.

28. Staka, G., Dragidella, F., & Disha, M. Anthropometric Study of Nasal Index of the Kosovo Albanian Population.

29. Tin, H. H. K., & Sein, M. M. (2011). Race identification for face images. ACEEE Int. J. Inform. Tech, 1(02), 35-37.

30. Tzou, C. H. J., Giovanoli, P., Ploner, M., & Frey, M. (2005). Are there ethnic differences of facial movements between Europeans and Asians?. British journal of plastic surgery, 58(2), 183-195.

31. Umar, M. B. T., Ojo, A. S., Asala, S. A., & Hambolu, J. O. (2011). Comparison of cephalometric indices between the Hausa and Yoruba ethnic groups of Nigeria.

32. Zappa, E., & Mazzoleni, P. (2010). Reliability of personal identification base on optical 3D measurement of a few facial landmarks. Procedia Computer Science, 1(1), 2769-2777.