

A Software Tool for Facial Analysis

¹Oghenemavwe Ese Loveday, ¹Fawehinmi Babatude Hakeem and ²Daenwin Tonye Lekara

¹Anatomy Department, Faculty of Basic Medical Sciences, College of Health Sciences,
University Of Port Harcourt, Port Harcourt, Rivers State. Nigeria

²Department of Computer Science, Faculty of Sciences, Madonna University, Elele,
Rivers State. Nigeria

Abstract: An accurate and thorough facial analysis is needed for the formulation of treatment plan in rhinoplastic, dental and aesthetic surgical procedures. The analysis process is not difficult but tedious due to accuracy requirements. Before technological advances, facial analysis was done manually to detect and interpret facial characteristics. This procedure is often time consuming with greater error due to parallax and approximation. The object of this study is to introduce a software tool design to simplify the analysis of facial parameters. 2D photographic images of the face captured under varying condition of illumination were analyzed with the aid of standard anatomical landmarks. Facial dimensions obtained were less time consuming and accurate. The software is capable of depicting and quantifying craniofacial dimensions and facial soft tissue profile at an increased speed and accuracy.

Key words: Angular measurements, anthropometry, facial analysis, linear measurements, software tool, 2D photogrammetry

INTRODUCTION

Medical specialties involved in the treatment of the face carry out accurate and thorough facial analysis when formulating the treatment plan. Facial analysis is the term used to describe detail examination of the features of the face using standard anatomical landmarks. It gives the dimension and spatial correspondence between definable points of the face. There are several methods used for facial analysis. These include manual anthropometry, cephalometric radiography, 2D photogrammetry and 3D stereophotogrammetry.

Manual anthropometry takes “direct” measurements from subject by making use of sliding and spreading calipers, flexible measuring tapes and protractors (Frakas, 1981; Didia and Dapper, 2005; Fawehinmi and Eroje, 2009; Oladipo *et al.*, 2010; Osunwoke *et al.*, 2011). The obvious advantage of this method is low cost of the equipment and its simple procedure. However, excessive time consumption and the possibility that equipment may distort the soft tissue and introduce errors in measurements is a major disadvantage.

Cephalometric radiography uses x-ray. From the x-ray films, anthropometric landmarks are used to determine facial dimension (Broadbent, 1981; El-Hadidy *et al.*, 2007). One merit of this method is that actual soft tissue

thickness can be evaluated especially from the lateral view x-ray. However, the exposure of subjects to x-ray is a major demerit of this method especially when it is for a research purpose. In addition, angular measurements are affected by enlargement in cephalometry (Malkoc *et al.*, 2005a, b).

2D photogrammetry may be analog or digital. Nevertheless, in recent times, 2D digital photography have become prevalent due to advances in technology. Image acquisition is relatively simple, equipments are cheap and a very high level of technical expertise may not be needed. One problem with 2D photography is the difficulty in measuring curve surfaces (Ozkul *et al.*, 2009)

The most common class of 3D surface imaging system is based on digital stereophotogrammetric technology. This system are accurately capable of reproducing surface geometry of the face, and map realistic color and texture data on the geometric shape resulting in a face that appears lifelike. This system offers a combination of fast acquisition speed and expanded surface coverage (Heike *et al.*, 2010). The obvious drawback of this method is the high cost of equipment, complex procedure and high level of expertise, which put it out of the reach of researchers in most developing countries.

It has been shown that all the three methods have comparable accuracy in producing results (Ghoddousi



Fig. 1: Frontal and lateral view photos and some soft tissue landmarks used in facial analysis: trichion (tr), glabella (g), nasion (n), endocanthion (en), exocanthion (ex), pronasale (Prn), subnasale (sn), zygion (zy), cheillion (ch), alare (al),

et al., 2007). Thus our aim is to introduce a software designed for 2D photogrammetry which can be conveniently used in clinical and research settings both in urban and rural areas

METHODOLOGY

Digital photographic set-up: The software tool is designed to analyze facial parameters from 2D photographs of subjects taken directly from a digital camera. It generates results in suitable formats that are easily exported to spreadsheets and databases. In taking the photograph, proper procedure for photography should be used to avoid distorted images. The photographic setup should consist of a tripod stand, a scaled graph paper background, a digital camera, a mirror and light sources (especially for indoors). The height of the tripod stand supporting the digital camera should be adjusted to the ear level of the subject. This adjustment allows the optical axis of the lens to be maintained at a horizontal position during recording. In addition, it confers stability on the camera when the “snap button” is pressed. This is not the case when it is held in the hand, as tremor and unconscious movement may result in a shift of the optical axis from horizontal position giving rise to a hazy or distorted image with the center focus of the face lost. To capture a photograph in the Natural Head Position (NHP), it is important that the subject be asked to relax his lip, place his hands beside his trunk and look at his eyes in a mirror, which is placed between 100-120 cm from him on the opposite side. The scaled graph sheet, which is placed behind the subject as a background is used as a guide to scale all photographic records to life size. This is essential for linear measurement but not for ratio or angular measurements.

Photography has been used as an excellent and convenient anthropometry tool for facial analysis and to compare pre and post operative outcome in facial plastic surgery (Larrabee, 1967; Andrews and Schoenrock, 1998). Images from any digital camera can be evaluated with this tool; however, the minimum resolution of the camera should be 640×480. Higher resolutions are better and therefore recommended, but photographic images produced at higher resolution should be “resized” to a resolution slightly lower than the computer screen resolution. This will eliminate any indirect effect of the computer screen resolution on the image. For example, if the uploaded image is 3012×2304 pixel and the computer screen resolution is 1300×760 pixel, the image should be resized to around 1280×740 pixel. This process can be carried out easily using any picture tool such as Microsoft Office Picture Manager, Picasa etc. The important thing to note is that no matter the resolution of the digital image it should be reduced slightly lower than the computer screen resolution.

Installation and set-up of software tool: The software tool was designed in 2010 by the Department of Human Anatomy, University of Port Harcourt, Nigeria, in collaboration with Daewin Infotech Resources, Port Harcourt, Rivers State, Nigeria. The software is compatible with Windows 7, Vista and XP Microsoft Software versions and it can be installed from the setup file. After installation, the “pro-image” icon will appear in the programme area. On clicking on the “pro-image” icon, the work page will appear on the screen. The page will display a blank sheet where the image to be analyzed can be uploaded and an image statistics sheet where the data of the image will be displayed. To upload an image, click on the “new image” icon in the menu bar. The software tool can analyze photographic images of the front and side views (Fig. 1).

Measurements of linear parameters: To measure linear dimensions, it is imperative that actual life size is obtained. This is done by clicking on the icon “analyse” and then on “facial width”. Thereafter, a known horizontal distance is created by clicking on two separate points on the graph sheet, which serve as a guide. The diameter of this distance should be wider than the breadth of the face. Finally, click on the “pixel per inch” icon on the menu toolbar and gradually adjust the numerical figures until the actual distance as indicated by the graph scale is obtained. This value will be shown on the image statistics sheet in the icon tagged “facial width”. For example, if the distance indicated by the graph sheet is 40 cm, 40 cm will also be indicated on the image statistics sheet under the icon “facial width”. The whole procedure is simple and the essence is to ensure that “real life size” measurements are obtained. Measurements can be made in pixel, centimeter, millimeter and inch units.

The following measurements can be obtain by the software:

- **Facial height (N-me):** This is the measured distance between the nasion and the menton.
- **Special head height (V-En):** This is the measured distance from the vertex to the endocanthion (Porter and Oslon, 2001).
- **Special face height (En-Gn):** This is the measured distance between the endocathion and meton.
- **Forehead height II (Tr-N):** This the measured distance between the trichion amd nasion (Porter and Oslon, 2001).
- **Nose length (n-sn):** This is the measured distance between the nasion and subnasale (Porter and Oslon, 2001).
- **Lower face height (Sn-Me):** This the measured distance between the subnasale and gnathion.
- **Forehead height I (Tr-G):** This is the measured distance between the trichion and the glabellar (Porter and Oslon, 2001).
- **Special upper face height 1 (G-Sn):** This is the measured distance between glabellar and subnasale (Porter and Oslon, 2001).
- **Ear length (Sa-Sba):** This the measured distance between superaurale and subaurale (Porter and Oslon, 2001).
- **Intercanthal distance (En-En):** This is the measured distance between the left and right endocanthion (Porter and Oslon, 2001).
- **Outer canthal distance (Exr-Exl):** This is the measured distance between the left and right exocanthion.
- **Nasal width (Al-Al):** This is the measured distance between the left and right alar (Porter and Oslon, 2001).

- **Nasal tip projection line (Sn-Prn):** This is the measured horizontal distance between the mid-facial vertical line and pronasale.
- **Eye fissure width (ex-en):** This is the measured distance between the exocanthion and endocanthion (Porter and Oslon, 2001).
- **Mouth width (Chr-Chl):** This the measured distance between the right and left cheillion.
- **Height of calva (v-tr):** This is the measured distance between the vertex and trichion (Porter and Oslon, 2001).
- **Lower nasal (Mn-Sn):** This the measured distance between the mid-nasal and subnasale.
- **Upper nasal height (N-Mn):** This the measured distance between the nasion and mid-nasal.

To measure these dimensions, click on the icons representing each of the anatomical parameters that serves as landmarks and placed them correctly on the appropriate position on the photograph. For example to measure the mouth width, click on icon “Chr” and place on the right cheillion and on the icon “Chl” and place on the left cheillion. The value for the mouth width will automatically appear on the image statistics sheet (Fig. 2).

Measurements of angular parameters: The angular dimensions that can measured by this tool include:

- **Nasofrontal angle (G-N-Prn):** It is formed by drawing a line tangent to the glabellar through the nasion that will intersect a line drawn tangent to nasal dorsum. (Powell and Humphreys, 1984)
- **Nasofacial angle:** It is formed by drawing a vertical line tangent to the forehead at the glabellar (G) and tangent to the chin at pogonion (Pg) so that a line drawn along the nasal dorsum (Nd) intersects it (Powell and Humphreys, 1984)

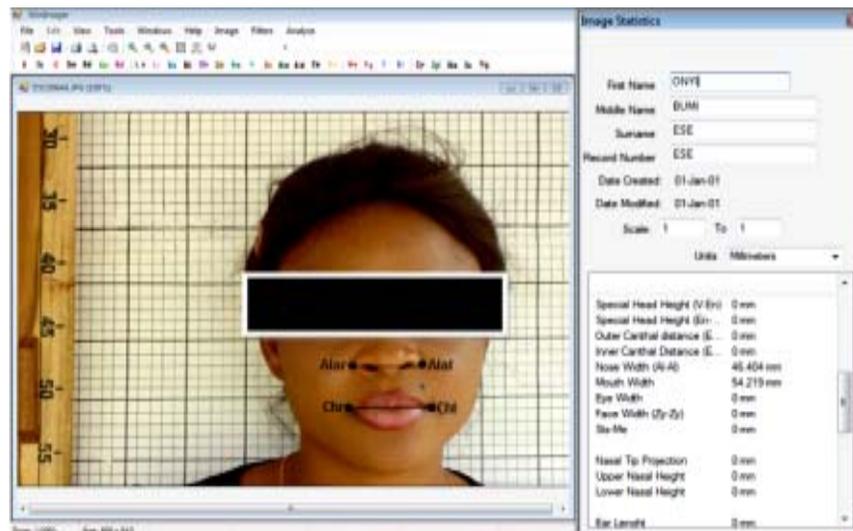


Fig. 2: Linear measurements: nose and mouth widths

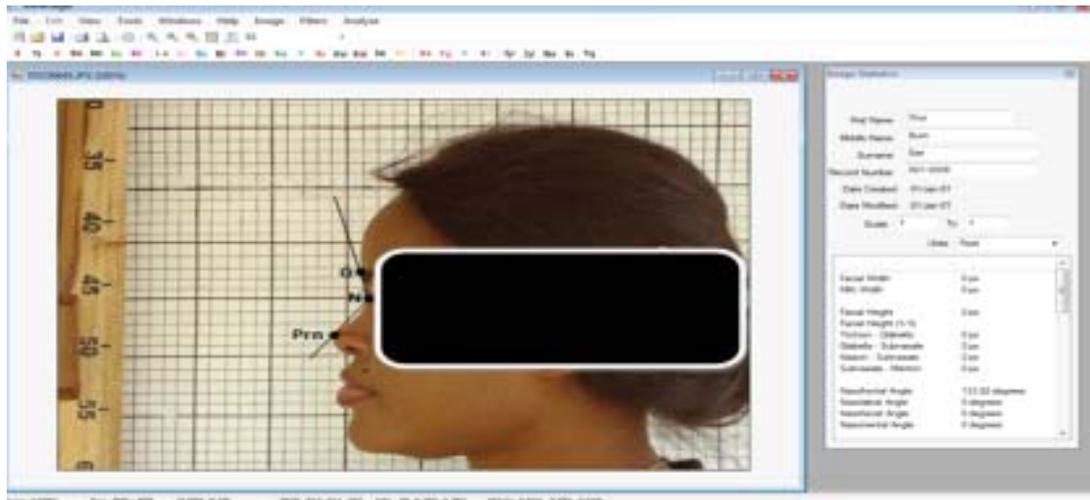


Fig. 3: Angular measurements: Nasofrontal angle

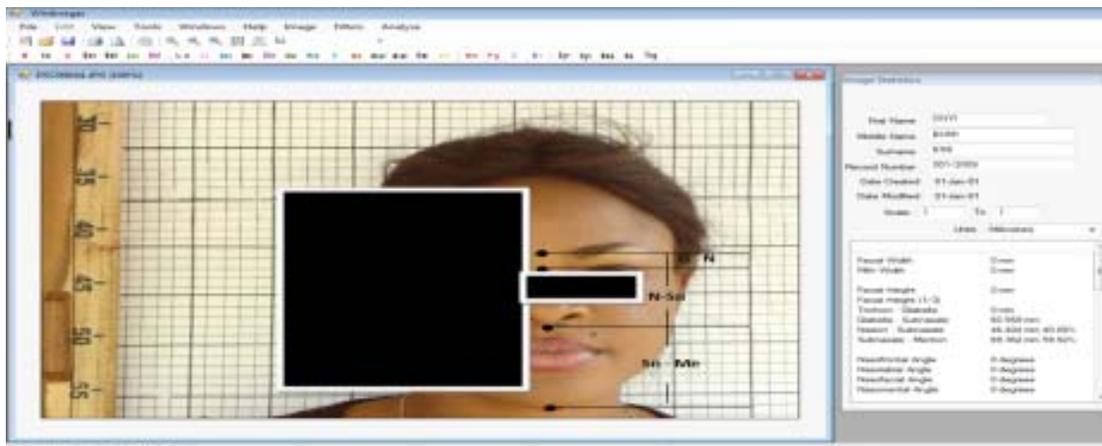


Fig. 4: Ratio measurements: Lower and upper face ratio

- **Nasomental angle (N-Prn-Pg):** It is formed by a line drawn from the nasion through the nasal dorsum intersecting a line drawn from the soft tissue chin pogonion at the pronasale (Powell and Humphreys, 1984)
- **Mentocervical angle (G-Pg/C-Me):** A vertical line tangent to the forehead passing through the glabella and pogonion intersecting a second line tangent to the menton (Powell and Humphreys, 1984)
- **Angle of total facial convexity:** It is the angle formed when two lines are drawn from the glabella to the pronasale and from the pronasale to the gnathion (Fernandez-Riveiro, 2003)
- **Angle of facial convexity:** The angle formed between the glabella, subnasale and gnathion. (Arnett and Bergman, 1993a, b)
- **Nasolabial angle (cm-sn-ls):** It is the angle formed at the subnasale by the intersection of the line passing

through columellar and another line passing through labial superius oris line (Powell and Humphreys, 1984)

- Angle of medium facial third
- Angle of Inferior facial third
- Vertical nasal angle
- Nose tip angle
- Mentolabial angle

To measure these angles, first upload the lateral view image of the subjects, then click icon that represent the anatomical landmark and place it correctly on the appropriate position in the photograph. For example, to measure the nasofrontal angle click on G “N” and “Prn” icons one at a time and placed them correctly at the appropriate position on the photograph. The value for the angle will automatically appear on the image statistics sheet (Fig. 3).

Measurement of middle and lower face ratios: The middle and lower face height ratio are measured in similar fashion as the linear measurements. As the middle and lower face heights are measured, the ratio of the middle to lower face height expressed in percentage will automatically displayed on the image statistics sheet (Fig. 4)

RESULTS AND DISCUSSION

Facial dimensions obtained where less time consuming and accurate. The accuracy of the tool was tested by carefully taking 100 photographs under the same photographic procedure as describe above. The same operator analyzed each photograph manually and by using the tool simultaneously. The result shows that the software tool can measure angles with an accuracy of up to 0.1 degree and 0.1 mm for linear measurements.

In this study, we have presented a software tool designed to evaluate linear and angular measurements of the face. The use of technology that allows for objective assessments of face are becoming increasingly important for research in dysmorphology, genetics, orthodontics, surgical disciplines and many others (Posnick and Farkas, 1994; Allanson, 1997; Moss *et al.*, 2003; Aung, 1999; Lee *et al.*, 2004). Although in a lot of developing countries such as Nigeria, the use of this new technology is limited by lack of equipment, technical “know how” and inadequate electricity supply. This can be resolve by this software tool because it uses relatively simple equipment such as a digital camera and computer that are not expensive and it is appropriate for clinical and research settings in both urban and rural areas. In addition, there is minimal invasiveness, quick capture speed, ability to archive images for subsequent analyses and a high degree of precision and accuracy. The safety, speed and reliability of data acquisition offered by this tool are particularly helpful when working with young children.

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