FACE ANTHROPOMETRY

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1.0 INTRODUCTIONS

Anthropometry is the measure of wo/man (anthro=man, pometry=measure). The study of anthropometry is the study of human body measurement for use in anthropological classification and comparison. Anthropometric data informs a range of enterprises that depend on knowledge of the distribution of measurements across human populations. For example, in human-factors analysis, a known range for human measurements can help guide the design of products to fit most people. In medicine, quantitative comparison of anthropometric data with patients' measurements before and after surgery furthers planning and assessment of plastic and reconstructive surgery.

In the 19th and early 20th centuries, anthropometry was a pseudoscience used mainly to classify potential criminals by facial characteristics. For example, Cesare Lombroso's Criminal Anthropology (1895) claimed that murderers have prominent jaws and pickpockets have long hands and scanty beards. The work of Eugene Vidocq, which identifies criminals by facial characteristics, is still used nearly a century after its introduction in France.

The most infamous use of anthropometry was by the Nazis, whose Bureau for Enlightenment on Population Policy and Racial Welfare recommended the classification of Aryans and non-Aryans on the basis of measurements of the skull and other physical features. Craniometric certification was required by law. The Nazis set up certification institutes to further their racial policies. Not measuring up meant denial of permission to marry or work, and for many it meant the death camps.

Today, anthropometry has many practical uses, most of them benign. For example, it is used to assess nutritional status, to monitor the growth of children, and to assist in the design of office furniture

2.0 FACE ANTHROPOMETRY

Face Anthropometric evaluation begins with the identification of particular locations on a subject, called landmark points, defined in terms of visible or palpable features (skin or bone) on the subject.

A series of measurements between these landmarks is then taken using carefully specified procedures and measuring instruments (such as calipers, levels and measuring tape). As a result, repeated measurements of the same individual (taken a few days apart) are very reliable, and measurements of different individuals can be successfully compared.

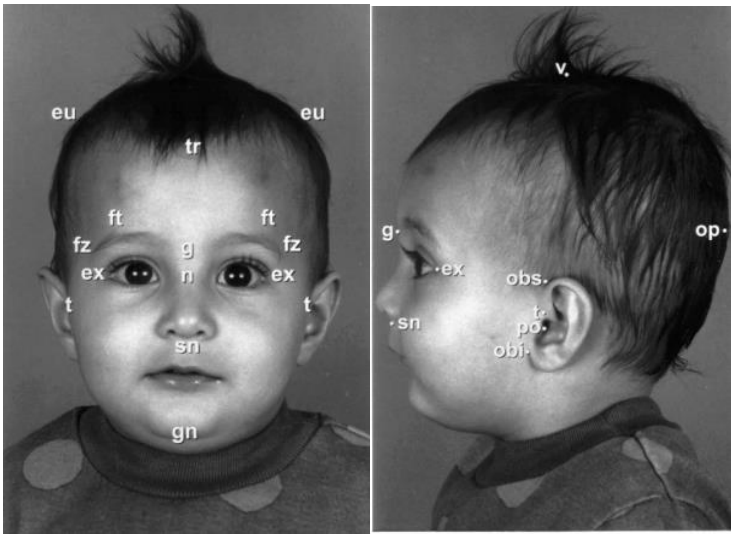
Farkas, provides a comprehensive overview of face anthropometry and its many significant applications. He defines face anthropometry in term of measurement taken from landmark of human faces. The measurement taken of the human face are of three kinds:

i. projective measurements (shortest distance between two landmarks)
ii. tangential measurements (distance between two landmarks measure along the skin surface)
iii. angular measurements.

Farkas, describes a widely used set of measurements for describing the human face. The system uses a total of 47 landmark points to describe the face. The landmarks are typically identified by abbreviations of corresponding anatomical terms.

Farkas also describes a total of 132 measurements on the face and head. Some of the measurements are paired, when there is a corresponding measurement on the left and right side of the face.

2.1. Farkas's Landmarks Point



en (endocanthion): the inner corner of the eye fissure where the eyelids meet.

- en-en (interocular distance), measured by sliding caliper: covering tips of caliper with index fingers, place fixed tip above subject's right endocanthion. Use 3rd and 5th fingers to steady Instrument above subject's face as you slide left tip to the left endocanthion.

eu (eurion): the most lateral point on the head (identified in opposition, see below)

- eu-eu (maximum cranial breadth), measured by spreading calipers: slide both tips of caliper down lateral sides of parietal bones, then move caliper tips forward and back until maximum width (eurions) is reached.
- fz r-eu I & fz I-eu r (cranial vault asymmetry), measured across the midline using spreading calipers: fz r-eu I; hold the tip of the caliper on the left eurion [eu-l], slide the other tip of the caliper to the anterior prominence of the right frontozygomaticus [fz-r]. Repeat on opposite side for fz I- eu r.

ex (exocanthion): the outer corner of the eye fissure where the eyelids meet.

- ex-ex (biocular width), measured by sliding caliper: covering tips of caliper as in en-en, place fixed tip of caliper above subject's right exocanthion, slide movable tip to position above subject's left exocanthion; use fingers to steady the instrument above the subject's face.
- ex-t (orbito-tragial distance, also referred to as upper cheek depth), measured on the left and right sides of the face using spreading calipers: hold the anterior tip of caliper to exocanthion, touch posterior tip lightly to tragus. Reverse for other side of face.

ft (frontotemporale): the most medial point on the temporal crest, identified by palpation.

- ft-ft (minimum frontal breadth), measured by spreading calipers: by palpation with index fingers, identify temporal crests of frontal bone. Continue along crests to the deepest (most medial) points of curves superior to the superior orbital rims; make sure caliper tips do not slip into temporal fossae.

fz (frontozygomaticus): the most lateral point on the frontozygomatic suture.

- fz-fz (supraorbital breadth-bony), measured by spreading caliper: place tips of caliper at the right and left frontozygomaticus.
- fz-g (supraorbital half-breadth), measured on the right and left sides of the head by sliding caliper: place the tip of the fixed arm at the frontozygomatic suture [fz] and slide the arm medially until it touches glabella.
- fz-g-fz (frontozygomaticus-glabella-frontozygomaticus), measured on the surface above the orbits using a measuring tape: place the tape at the origin of the right frontozygomaticus, guiding the tape over glabella to the left frontozygomaticus.
- fz r-eu l & fz l-eu r (cranial vault asymmetry), measured across the midline using spreading calipers: fz r-eu l; hold the tip of the caliper on the left eurion [eu-l], slide the other tip of the caliper to the anterior

prominence of the right frontozygomaticus [fz-r]. Repeat on opposite side for fz l- eu r.

- fz r-t l & fz l- t r (frontal-orbital asymmetry), measure across the midline using spreading calipers: fz r-t l: hold the tip of the caliper on the left tragus [t-l], slide the other tip of the caliper to the right frontozygomaticus [fz-r]. Reverse for opposite side for fzl-tr.

g (glabella): the most prominent point in the median sagittal plane between the supraorbital ridges.

- Head circumference, measured by tape: encircle the tape around the head covering glabella [g] and opisthocranion [op], do not stretch tape too tightly.
- g-op (maximum cranial length), measured by spreading caliper: with anterior caliper tip resting on glabella, slide posterior tip inferiorly along medial line of occipital until maximum width is reached (opisthocranion). Conventional technique keeps calipers along a sagittal midline; however, in patients with plagiocephaly, the posterior point of the skull may not be in the midline of the cranium. For clinical purposes take this measurement at the most posterior location.
- fz-g (supraorbital half-breadth), measured on the right and left sides of the head by sliding caliper: place the tip of the fixed arm at the frontozygomatic suture [fz] and slide the arm medially until it touches glabella.
- fz-g-fz (frontozygomaticus-glabella-frontozygomaticus), measured on the surface above the orbits using a measuring tape: place the tape at the origin of the right frontozygomaticus, guiding the tape over glabella to the left frontozygomaticus.

gn (gnathion): in the midline, the lowest point on the lower border of the chin.

- n-gn (morphological height of face), meausured by sliding caliper: place the fixed tip of caliper at the subject's gnathion, slide the moveable end superiorly until it contacts nasion.

- gn-t (lower face depth), measured on the left and right sides of the face using spreading calipers: similar to mid face depth, place the anterior tip of the caliper to the anterior point of gnathion and touch posterior tip lightly to tragus. Reverse for other side of face.
- v-gn (total craniofacial head height), measured in the midline using a double sliding caliper and a level.

obi (otobasion inferius): the lowest point of attachment of the exteral ear to the head.

obs (otobasion superius): the highest point of attachment of the exteral ear to the head.

op (opisthocranion): the most prominent posterior point on the occiput.

- Head circumference, measured by tape: encircle the tape around the head covering glabella [g] and opisthocranion [op], do not stretch tape too tightly.
- g-op (maximum cranial length), measured by spreading caliper: with anterior caliper tip resting on glabella, slide posterior tip inferiorly along medial line of occipital until maximum width is reached (opisthocranion). Conventional technique keeps calipers along a sagittal midline; however, in patients with plagiocephaly, the posterior point of the skull may not be in the midline of the cranium. For clinical purposes take this measurement at the most posterior location.

po (porion): the most superior point on the upper margin of the external auditory meatus with the head in the Frankfort horizontal plane.

- v-po (auricular head height) measured on the right and left sides of the head using a double sliding caliper and a level.

n (nasion): the midpoint of the nasofrontal suture.

- n-gn (morphological height of face), meausured by sliding caliper: place the fixed tip of caliper at the subject's gnathion, slide the moveable end superiorly until it contacts nasion.
- n-t (upper face depth), measured on the right and life sides of the face using spreading calipers: place the anterior tip of the caliper at nasion [n] and touch the posterior tip lightly to tragus [t]. Reverse for other side of face.
- v-n (anterior head height), measured in the midline using a double sliding caliper and a level.

sn (subnasale): in the midline, the junction between the lower border of the nasal septum and the cutaneous portion of the upper lip.

- sn-t, (mid face depth), measured on the right and left sides of the face using spreading calipers: place the anterior tip of the caliper at subnasale [sn] and touch the posterior tip to tragus [t]. Reverse for other side of face.

t (tragion): at the notch above the tragus of the ear where the upper edge of the cartilage disappears into the skin of the face.

- t-t (cranial base width), measured by sliding caliper: the tragi are soft tissue landmarks; tips of caliper should gently touch the superior margins of tragi.
- ex-t (orbito-tragial distance, also referred to as upper cheek depth), measured on the left and right sides of the face using spreading calipers: hold the anterior tip of caliper to exocanthion, touch posterior tip lightly to tragus. Reverse for other side of face.
- fz r-t l & fz l- t r (frontal-orbital asymmetry), measure across the midline using spreading calipers: fz r-t l: hold the tip of the caliper on the left tragus [t-l], slide the other tip of the caliper to the right frontozygomaticus [fz-r]. Reverse for opposite side for fzl-tr.
- gn-t (lower face depth), measured on the left and right sides of the face using spreading calipers: similar to mid face depth, place the anterior

tip of the caliper to the anterior point of gnathion and touch posterior tip lightly to tragus. Reverse for other side of face.

- n-t (upper face depth), measured on the right and life sides of the face using spreading calipers: place the anterior tip of the caliper at nasion [n] and touch the posterior tip lightly to tragus [t]. Reverse for other side of face.
- sn-t, (mid face depth), measured on the right and left sides of the face using spreading calipers: place the anterior tip of the caliper at subnasale [sn] and touch the posterior tip to tragus [t]. Reverse for other side of face.

tr (trichion): the midpoint of the hairline.

v (vertex): the highest point on the head with the head in the Frankfort horizontal plane.

- v-gn (total craniofacial head height), measured in the midline using a double sliding caliper and a level.
- v-po (auricular head height) measured on the right and left sides of the head using a double sliding caliper and a level.
- v-n (anterior head height), measured in the midline using a double sliding caliper and a level.

zy (zygion): the most lateral point on the zygomatic arch.

- zy-zy (maximum facial breadth), measured by spreading caliper: by palpation locate the most lateral point of the zygomatic arch with the tips of index fingers and place the caliper tips on the arches with enough pressure to feel the bone. Move the caliper back and forth, up and down until scale shows maximum reading.

Systematic collection of anthropometric measurements has made possible a variety of statistical investigations of groups of subjects.

3.0 LITERATURE VIEWS

Many researchers(Hyatt etal.,1972; Oestenstadetal., 1990) have recognized that leakages of the respirator have close association with sizing design of the respirator and facial dimensions in the fittest panel. The proper facial dimensions will make respirator design and sizing suitable for tight-fitting with the wearer's face (Hack and Mc Con-ville, 1978). Hence, facial anthropometric dimensions must be considered for defining respirator test panels in order to design respirators successfully (NIOSH,1972; Zhuang, 2004; Zhuang,2007), especially for diverse ethnic groups (Han andChoi,2003; Kim etal.,2003; Yokota,2005).

Anthropometric data are one of essential factors in designing machines and devices (Mebarki and Davies, 1990). Incorporating such information would yield more effective designs, ones that are more user friendly, safer, and enable higher performance and productivity. The lack of properly designed machines and equipment may lead to lower work performance and higher incidence of work-related injuries (Botha and Bridger,1998).

Anthropometry has been critical to successfully designing and sizing protective helmets, eyewear, and respirators in the US Army. Compared to early demography based primarily on White males, the anthropometric distribution of the US Army has changed since individuals of diverse ethnic backgrounds began serving in the 1960s (Bradtmiller et al., 1985; Brues, 1945;Gordon, 1996). Such demographic changes may affect the anthropometric distributions of the populations for which military equipment was designed.

Current US Army ergonomics are based on the 1988 US Army anthropometric survey (ANSUR) database (Gordon et al., 1989), weighted for primary racial groups and different age proportions in each gender throughout US Army demography.

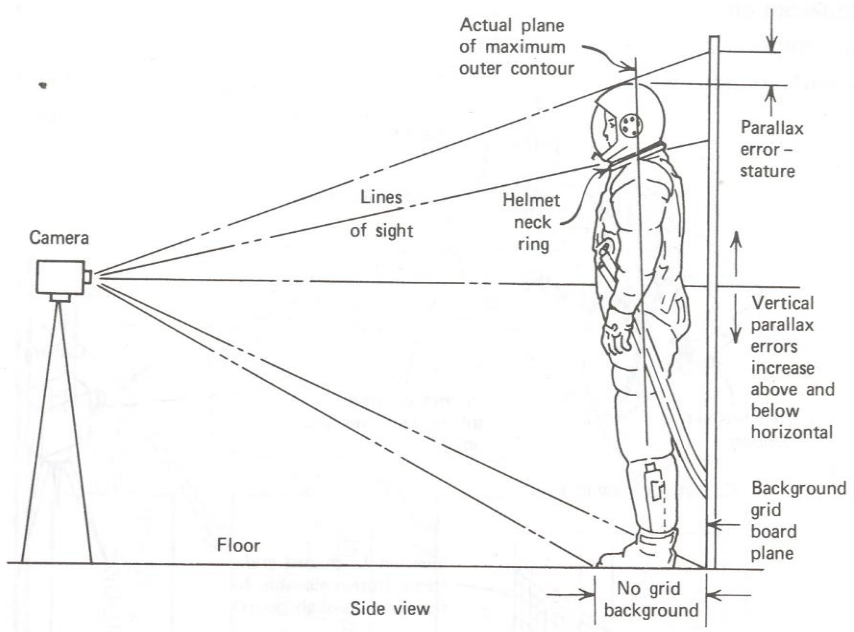
However, despite the fact that the number of biologically admixed populations is increasing in the US (Gibson and Lennon, 1999), there have been few related ergonomic studies. This study investigated differences in multivariate head and face anthropometric distributions between biologically admixed male individuals and single racial male groups (Whites or Blacks).

The goal of this study was to examine the effect that an increasingly admixed US Army population might have on current and future equipment sizing and design statistics. The U.S. military, in particular, has performed a number of comprehensive anthropometric studies to provide information for use in the design of military clothing and equipment (Gordon et al., 1989).

In recent years, traditional measurement techniques, performed manually with such instruments as calipers and measuring tapes, have been supplemented, and even in some cases replaced, by three-dimensional (3D) scans and digitizers.

To record and extract useful numerical information about subject’s size and shape, use is often made of number of measurement scales, grids, or markers in 3D space placed around the subject.

One common practice is to place a vertical plate marked with two dimensional grid lines behind the subject (Li Hwang, and Wang, 1990). But this method can lead to major errors of parallax as shown in below figure.



Thus to avoid parallax errors, either more camera locations are required or other markers must be placed at known locations within the field of view.

However, if the subject and camera location are known, trigonometric calculations can be used to correct for much of the parallax error (Roebuck et al., 1975). Thus, this method was used recently as 1989 by Li et al. (1990) using special computer software to calculate the corrections.

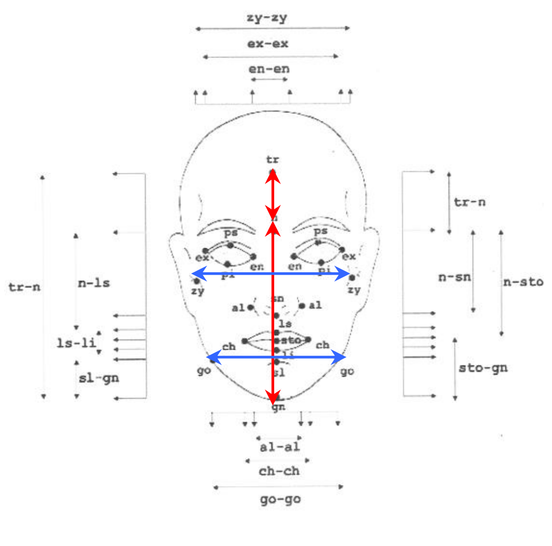
4.0 PROBLEM STATEMENT

Recently Malaysian Army faced the problem with the face mask used for their operation. The face mask was not tight fitting with the wearer's face. This is due to the face mask size were base on to the European Army.
Since the face anthropometry was differ between ethnic (Han andChoi,2003; Kim etal.,2003; Yokota,2005), Malaysian Army should perform their own face anthropometry in order to encounter this problem. The proper facial dimensions will make respirator design and sizing suitable for tight-fitting with the wearer's face (Hack and Mc Con-ville, 1978).

5.0 CONSTRAINS

5.1. Scope of Frakar's Landmark Point

There are only four point of landmark involved in for the purpose of this research. The point involved were



i. tr-n - Entocanthion to trichion
ii. n-gn - Entocanthion to gnathion height
iii. zy-zy - Bitragion breadth
iv. go-go - Bigonial breadth

5.2. Sample

Forty samples were taken for this measureant. And it all was the male students at the Polytechnic Merlimau, Malacca.

5.3. Measurement Tools

i. Venire Caliper
   To record the measurement the actual dimension of landmark point.
ii. Camera position and usability Vision Assisted Anthropometric Measurement System (VAAMS) software.

6.0 OBJECTIVE

The objective of this measureant is to

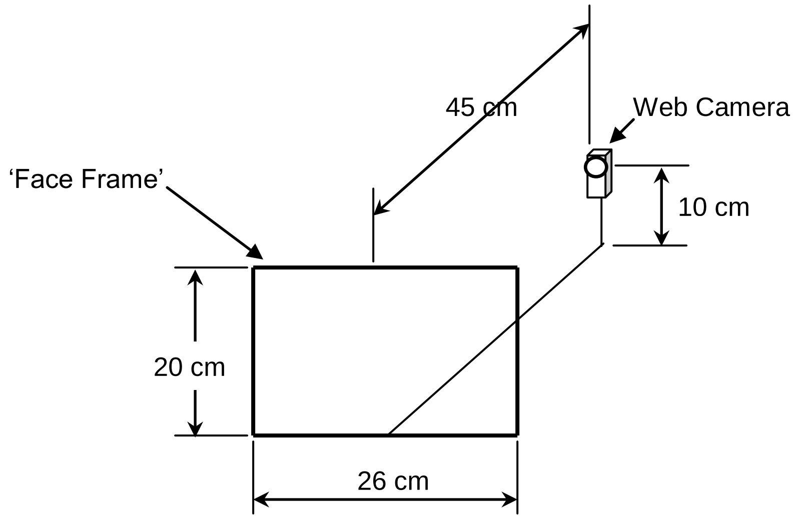
i. Figure out the Malaysian Male face anthropometry.
ii. Justify the reliability of VAAMS system.

7.0 METHODOLOGY

Measurement process comprise of the hardware setup for the face frame and web camera position and usability of measurement software called Vision Assisted Anthropometric Measurement System (VAAMS).

7.1. Orientation of face frame and web camera

Size of the face frame was 26 cm x 20cm. The camera is oriented at the centered of the face frame and at distance of 45 cm from the face frame surface.



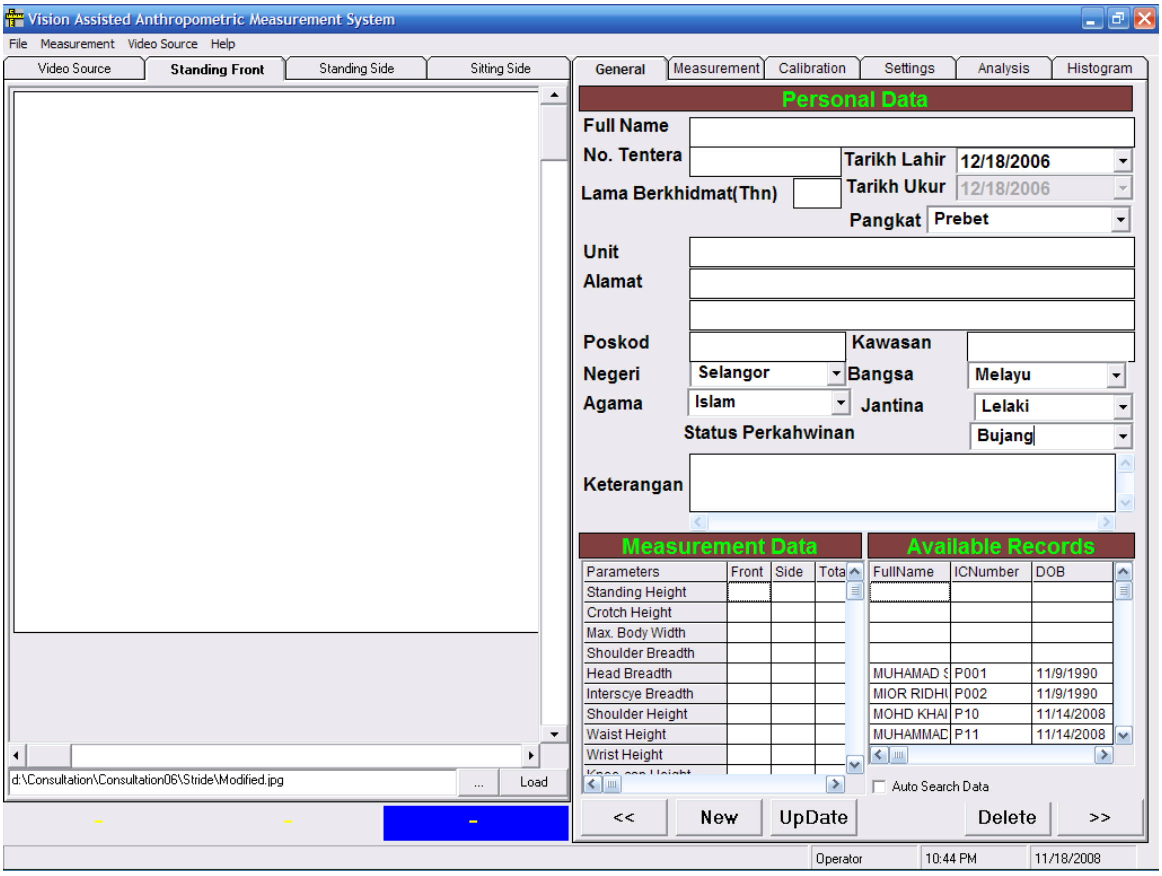
i. 'Face Frame' Background

The frame design to be 0.26m width by 0.20 m height which is suitable for population height and breadth of Malaysian people faces. The value of width could be modified to be greater than this.

This image has been used during the calibration between the real dimension and calibration image in the software.

7.2. Software (Vision Assisted Anthropometric Measurement System (VAAMS))

Below is the figure of the panel for the VAAMS software

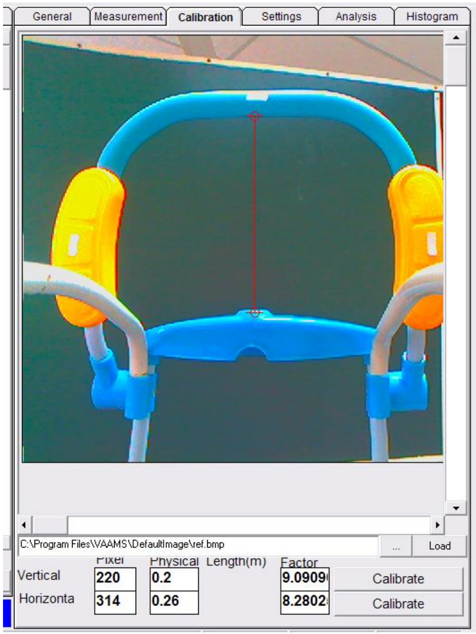


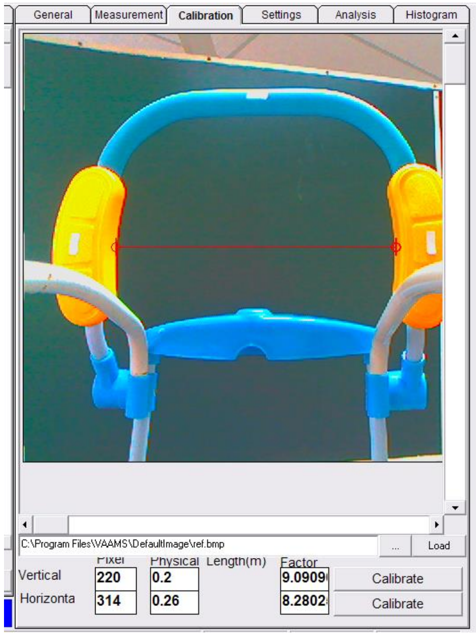
i. Calibration and Setting

Before the software can be used it has to be calibrated first. As stated before, the face frame image shown before has been used during the calibration between the real dimension and calibration image in the software to get the calibration factor between the images. The calibration factor is important as the factor for the setting image in horizontal and vertical during the measurement.

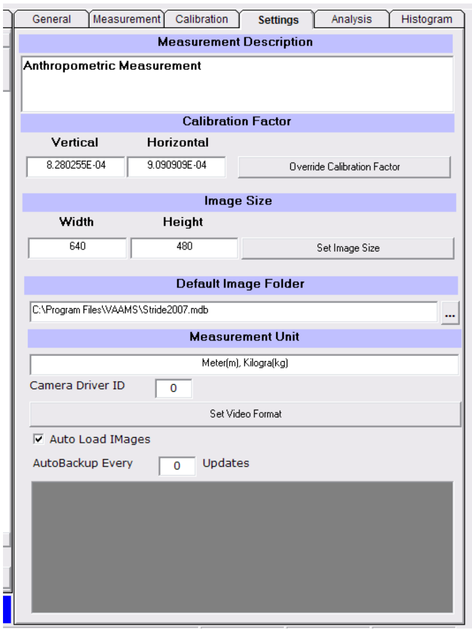
During the calibration, image for calibration has been uploaded first. Then measurement for calibration on the image was performed. As shown in figure above, the vertical calibration for the image has been done. The summary of the calibration are:

	Vertical (height)	Horizontal (wide)
Calibration factor	9.0909	8.2802
Physical	0.20 m	0.26 m
Pixels	220	314





Both factors then was put in to the setting value of the software



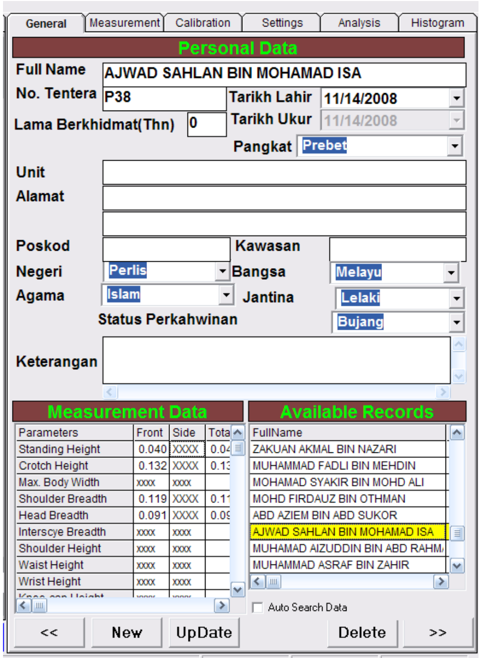
7.3. Measurement

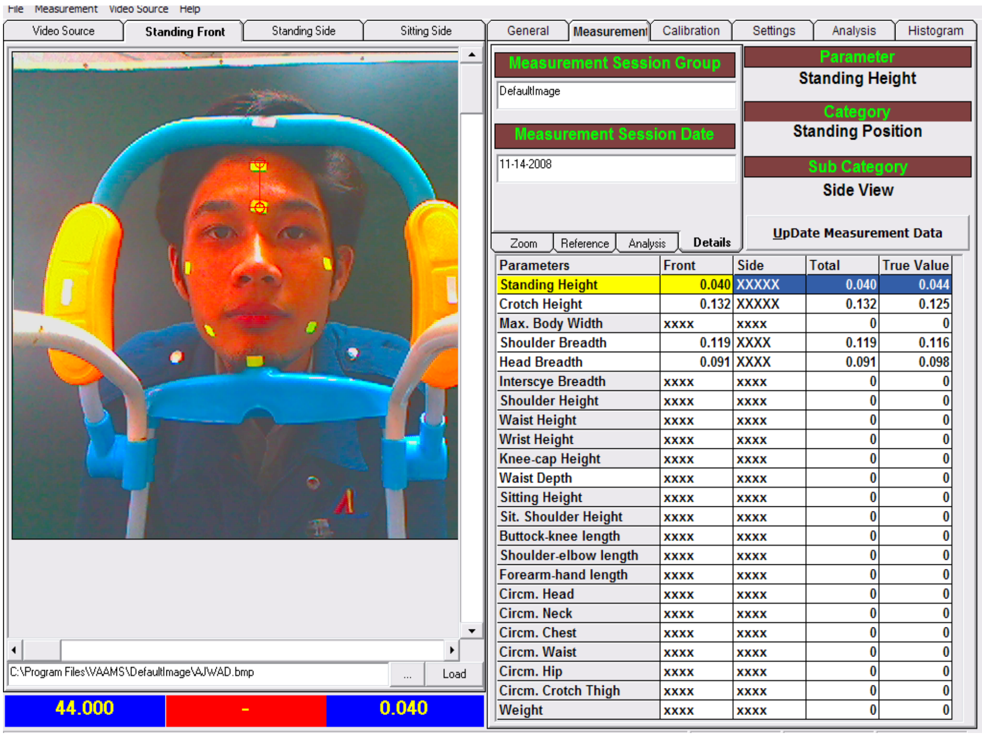
After the completion of the calibration and setting process in the software, the measurement process can be start.

Firstly, the web camera must be proper connected. Then the personal data for the sample will be recoded before the calibrating the face of the sample taking place.

The image of standing front type for the sample face anthropometry then captured. The landmark point involved was Entocanthion to trichion, Entocanthion to Gnathion height, Bitragion breadth and Bigonial breadth. The landmark point then measured and recoded in to the related parameter.

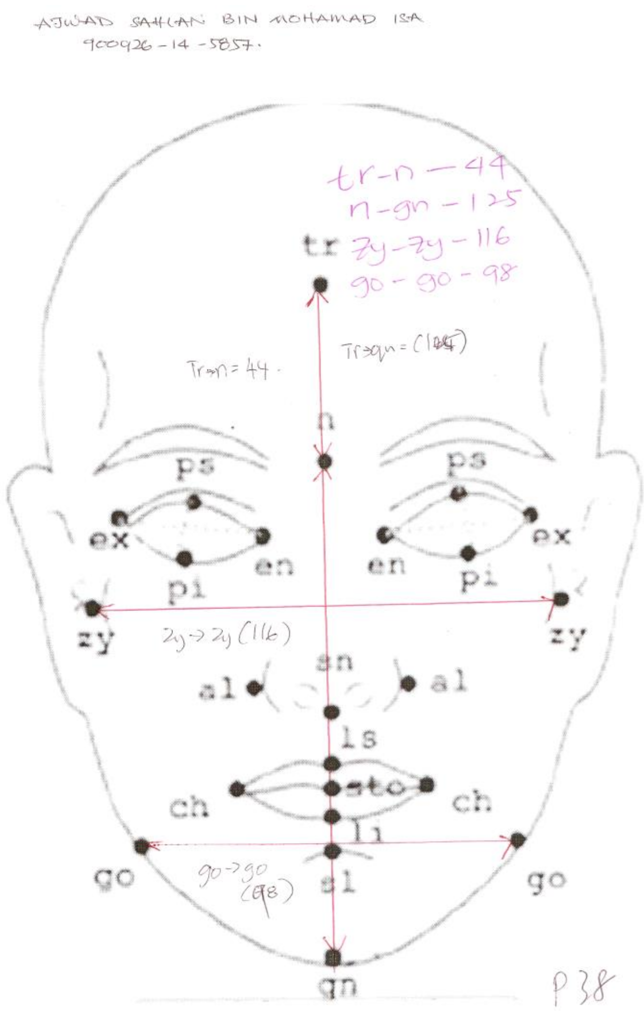
Below is the field involved in the VAAMS to record the related measurement.





The sequence was repeated until the reading needed for the entire sample was completed.

The actual dimension of the land mark point also measured with the vernier calipers in order to make a comparison with the value result from the VAAMS software.



8.0 RESULT

After the physical measurement process using the VAAMS software finished, the date was transferred to Microsoft Office-Excel program. Data of 40 samples then summarized as below:

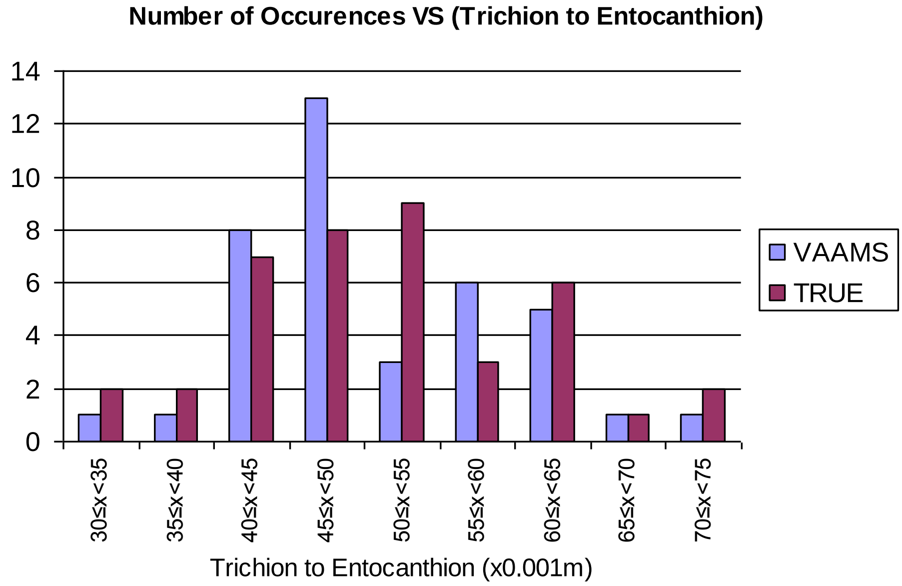
UMBER	NAME	IC NUMBER	LANDMARKS POINT (METER) TRICHION TO ENTOCANTHION			ENTOCANTHION TO GNATHION			BIZYGOMATIC BREADTH			BIGONIAL BREADTH		
			VAAMS	TRUE	ERROR	VAAMS	TRUE	ERROR	VAAMS	TRUE	ERROR	VAAMS	TRUE	ERROR
1	MUHAMAD SYAMEER BIN MASHOODI	P1	0.055	0.054	0.02	0.129	0.125	0.032	0.123	0.125	-0.016	0.113	0.115	-0.017
2	MIOR RIDHUAN BIN MIOR AHMAT ZAUDI	P2	0.050	0.053	-0.06	0.142	0.139	0.022	0.118	0.115	0.026	0.083	0.080	0.038
3	MOHAMAD SAFWAN BIN SARIKAT	P3	0.063	0.065	-0.03	0.123	0.117	0.051	0.115	0.119	-0.034	0.089	0.087	0.023
4	MUHAMMAD ASRAF BIN ZAHIR	P4	0.046	0.045	0.02	0.127	0.121	0.050	0.123	0.121	0.017	0.092	0.094	-0.021
5	MOHD KHAIRUL BIN MAMAT	P5	0.040	0.043	-0.07	0.145	0.139	0.043	0.127	0.130	-0.023	0.093	0.091	0.022
6	NIK MOHAMAD SYAHMI BIN NIK IBRAHIM	P6	0.044	0.043	0.02	0.125	0.125	0.000	0.123	0.126	-0.024	0.079	0.077	0.026
7	MOHD FIRDAUS BIN HASHIM	P7	0.042	0.041	0.02	0.130	0.127	0.024	0.112	0.110	0.018	0.078	0.076	0.026
8	MOHD FAUZI BIN SALLEH	P8	0.045	0.044	0.02	0.130	0.118	0.102	0.117	0.120	-0.025	0.084	0.083	0.012
9	KHAIRUL ANUAR BIN KARIM	P9	0.049	0.050	-0.02	0.120	0.110	0.091	0.118	0.120	-0.017	0.090	0.090	0.000
10	MOHD KHAIRUDIN BIN MISLAN	P10	0.044	0.040	0.10	0.141	0.130	0.085	0.107	0.110	-0.027	0.073	0.070	0.043
11	MUHAMMAD AFIQ BIN YAAKOB	P11	0.061	0.063	-0.03	0.119	0.114	0.044	0.123	0.127	-0.031	0.098	0.097	0.010
12	MUHAMAD ALI ZULFIKRI BIN MD ISKANDAR	P12	0.047	0.048	-0.02	0.135	0.129	0.047	0.117	0.121	-0.033	0.090	0.085	0.059
13	MUHD HAIQAL BIN JOHARI	P13	0.060	0.061	-0.02	0.139	0.129	0.078	0.117	0.117	0.000	0.093	0.096	-0.031

14	MUHAMMAD SOLLEHIN BIN HAMID	P14	0.046	0.043	0.07	0.138	0.130	0.062	0.114	0.112	0.018	0.101	0.102	-0.010
15	AMALUL ARIFIN BIN MAHFUD	P15	0.045	0.049	-0.08	0.135	0.126	0.071	0.119	0.126	- 0.056	0.110	0.109	0.009
16	MUHAMMAD ARIEF FARHAN	P16	0.054	0.052	0.04	0.133	0.127	0.047	0.124	0.127	- 0.024	0.120	0.123	-0.024
17	MUHAMMAD NAZREEN BIN MOHD NASIR	P17	0.046	0.050	-0.08	0.143	0.125	0.144	0.120	0.125	- 0.040	0.095	0.100	-0.050
18	MOHAMAD HAFIZ HAIKAL BIN KAMARUZAMEND	P18	0.056	0.059	-0.05	0.128	0.120	0.067	0.131	0.130	0.008	0.108	0.110	-0.018
19	MOHD IZWAN BIN MAT	P19	0.045	0.048	-0.06	0.128	0.123	0.041	0.123	0.122	0.008	0.097	0.096	0.010
20	MOHD SHAFIEE BIN MUZID	P20	0.055	0.058	-0.05	0.127	0.123	0.033	0.110	0.114	- 0.035	0.068	0.070	-0.029
21	SYAMIL BIN ROSEDIN	P21	0.045	0.049	-0.08	0.130	0.126	0.032	0.118	0.121	- 0.025	0.065	0.066	-0.015
22	MOHAMAD EZWAN BIN HASHIM	P22	0.059	0.061	-0.03	0.125	0.118	0.059	0.119	0.124	- 0.040	0.098	0.113	-0.133
23	GUNASEKARAN A/L MOKHAN	P23	0.062	0.060	0.03	0.121	0.115	0.052	0.116	0.120	- 0.033	0.110	0.110	0.000
24	MUHAMMAD ZAHID BIN KAMARUDIN	P24	0.052	0.050	0.04	0.129	0.130	- 0.008	0.126	0.129	- 0.023	0.118	0.123	-0.041
25	MOHD HILMI BIN MOHD ARIS	P25	0.037	0.033	0.12	0.129	0.115	0.122	0.100	0.095	0.053	0.091	0.088	0.034
26	MOHAMAD NAZRIN BIN ABDUL MAJID	P26	0.068	0.071	-0.04	0.128	0.126	0.016	0.123	0.127	- 0.031	0.104	0.102	0.020
27	AHMAD KHAIRUL MUZZAMMIL BIN JAMAL ABDUL NASIR	P27	0.050	0.053	-0.06	0.134	0.124	0.081	0.142	0.140	0.014	0.103	0.102	0.010
28	HAIZAT BIN MESPAN	P28	0.041	0.038	0.08	0.131	0.123	0.065	0.109	0.113	- 0.035	0.094	0.090	0.044
29	RIDHWAN HAFIZ BIN MOHAMED SALEH	P29	0.061	0.070	-0.13	0.141	0.135	0.044	0.122	0.125	- 0.024	0.092	0.095	-0.032
30	DION PRIMA PUTRA BIN MARDONI	P30	0.049	0.046	0.07	0.125	0.120	0.042	0.120	0.118	0.017	0.091	0.092	-0.011
31	MUHAMMAD SALIHN BIN MOHD RASHAD	P31	0.045	0.046	-0.02	0.133	0.126	0.056	0.12	0.126	- 0.048	0.096	0.100	-0.040
32	MUHAMAD ZULHILMI BIN KAHARUDDIN	P32	0.065	0.060	0.08	0.118	0.114	0.035	0.123	0.120	0.025	0.085	0.086	-0.012

33	ZAKUAN AKMAL BIN NAZARI	P33	0.047	0.050	-0.06	0.132	0.127	0.039	0.125	0.125	0.000	0.071	0.070	0.014
34	MUHAMMAD FADLI BIN MEHDIN	P34	0.056	0.060	-0.07	0.134	0.128	0.047	0.128	0.130	-0.015	0.078	0.077	0.013
35	MOHAMAD SYAKIR BIN MOHD ALI	P35	0.032	0.030	0.07	0.129	0.127	0.016	0.112	0.114	-0.018	0.093	0.098	-0.051
36	MOHD FIRDAUZ BIN OTHMAN	P36	0.043	0.045	-0.04	0.129	0.123	0.049	0.115	0.121	-0.050	0.085	0.089	-0.045
37	ABD AZIEM BIN ABD SUKOR	P37	0.043	0.039	0.10	0.142	0.135	0.052	0.110	0.115	-0.043	0.096	0.097	-0.010
38	AJWAD SAHLAN BIN MOHAMAD ISA	P38	0.040	0.044	-0.09	0.132	0.125	0.056	0.119	0.116	0.026	0.091	0.098	-0.071
39	MUHAMAD AIZUDDIN BIN ABD RAHMAN	P39	0.056	0.059	-0.05	0.132	0.129	0.023	0.123	0.125	-0.016	0.087	0.091	-0.044
40	AZRI BIN HAMDAN	P40	0.045	0.050	-0.10	0.135	0.129	0.047	0.114	0.115	-0.009	0.096	0.097	-0.010
	Average		0.050	0.051	-0.011	0.131	0.125	0.051	0.119	0.121	-0.014	0.092	0.093	-0.008
	Maximum Value		0.068	0.071	0.121	0.145	0.139	0.144	0.142	0.140	0.053	0.120	0.123	0.059
	Minimum Value		0.032	0.030	-0.129	0.118	0.110	-0.008	0.100	0.095	-0.056	0.065	0.066	-0.133
	Standard Deviation		0.008	0.009	0.064	0.007	0.007	0.030	0.007	0.008	0.025	0.013	0.014	0.036

9.0 ANALYSIS

9.1. Entocanthion to Trichion



From the graph above, it shows that the number of occurrences is highest for trichion to entocanthion at $(45 \leq x < 50)\times10^{-3}$ m for true reading. While the measureant using VAAMS software it shows that the highest for trichion to entocanthion, is at $(50 \leq x < 55)\times10^{-3}$ m with the number of occurrence is 8.

The true value for this landmark point is the value of the true value since measureant values taken by VAAMS were easily interfered which causes an error in reading. (The factors involved will be discussed later)

By taken the probability of measuring distance (trichion to entocanthion), P% as 90%, the error within true error and VAAMS system for this landmark point can be calculated.

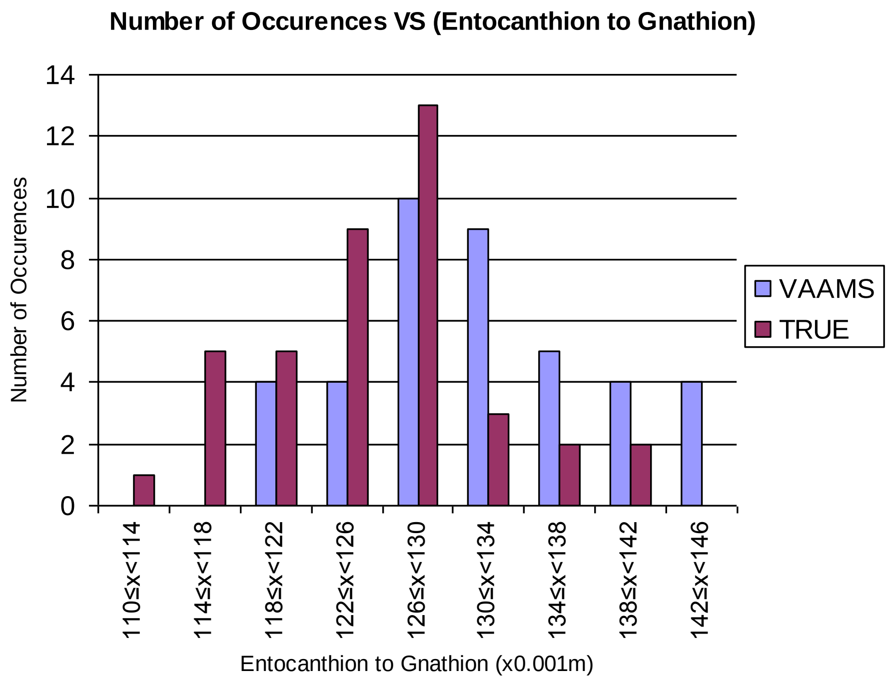
$$e_i = \bar{e} \pm \sigma z$$

$$e_i = -0.011 \pm (0.064)(1.96)$$

$$= -0.011 \pm 0.125$$

$e_{min} = -0.136$ $\quad$ $e_{max} = 0.114$

9.2 Entocanthion to Gnathion



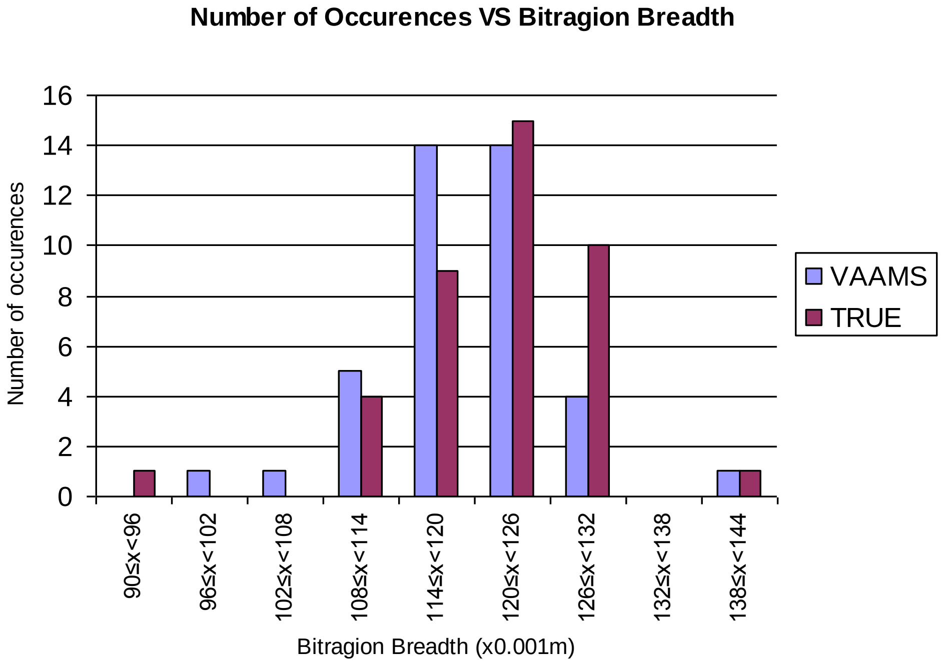
From the graph above, it shows that the number of occurrences is highest for entocanthion to gnathion at $(126 \leq x < 130)\times10^{-3}$ m for both true and VAAMS system reading. Then this land mark value can be determine as a true value for entocanthion to gnathion value.

By taken the probability of measuring distance (Entocanthion to Gnathion), P% as 90%, the error within true error and VAAMS system for this landmark point can be calculated.

$$e_i = \bar{e} \pm \sigma z$$
$$= 0.051 \pm (0.030)(1.96)$$
$$= 0.051 \pm 0.059$$

$e_{min} = -\ 0.008$ $\qquad$ $e_{max} = 0.110$

9.3 Bitragion Breadth



The true value for the Bitragion Breadth is at (120≤ x < 126)x10^{-3} m, where both (the true and VAAMS system) value show at highest number of occurrence.

By taken the probability of measuring distance (Bitragion Breadth), P% as 90%, the error within true error and VAAMS system for this landmark point can be calculated.

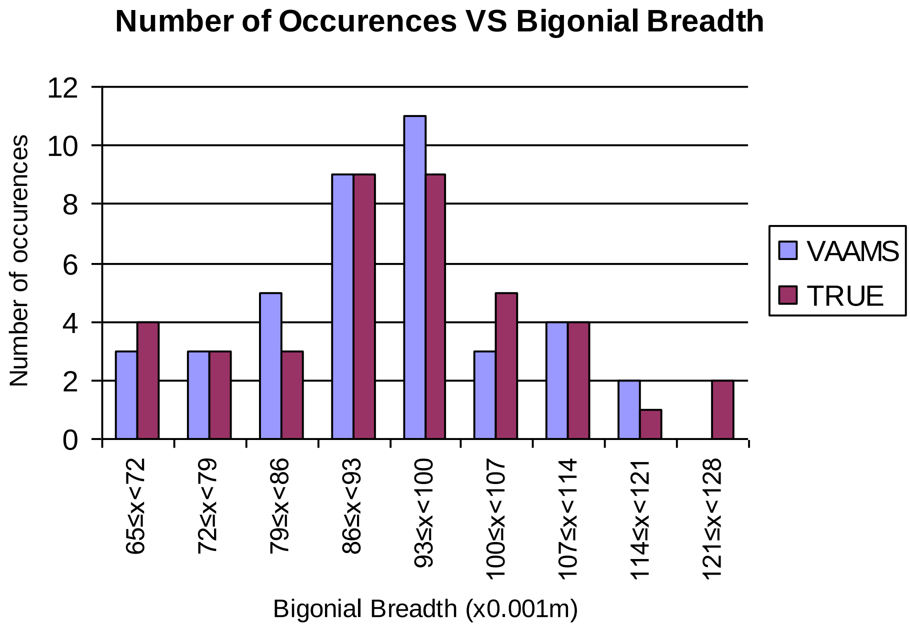
$$e_i = \bar{e} \pm \sigma z$$

$$= -0.014 \pm (0.025)(1.96)$$

$$= -0.014 \pm 0.049$$

e_{min} = - 0.063 e_{max} = 0.035

9.4 Bigonial Breadth



The true value for the Bigonial Breadth is at $(93 \le x < 100) \times 10^{-3}$ m, where both (the true and VAAMS system) value show at highest number of occurance.

By taken the probability of measuring distance (Bigonial Breadth), P% as 90%, the error within true error and VAAMS system for this landmark point can be calculated.

$$e_i = \bar{e} \pm \sigma z$$

$$= -0.008 \pm (0.036)(1.96)$$

$$= -0.008 \pm 0.071$$

$$e_{min} = -0.079 \qquad e_{max} = 0.063$$

The measureant conduct shows that the face anthropometries for Malaysian with male in gender are as below

Face Landmark	Size
Trichion to Entocanthion	(50 – 55) mm
Entocanthion to Gnathion	(126 – 130) mm
Bitragion Breadth	(120 – 126) mm
Bigonial Breadth	(93 – 100) mm

10.0 DISCUSSION

Anthropometric data not always as reliable as they appear since many factors come involved during the measurement of human subjects, which can result in the appearance of numerous sources of error such as:

a) Pre-processing of the front images,
b) Calibration of the cameras,
c) Segmentation of the body from the background,
d) Detection of landmarks, and
e) Calculation of the anthropometric dimensions.

The difficulty in controlling all potential sources of error is such that it has been said that true values are seldom measured in anthropometry. Accuracy and precision of anthropometric measurements are at the mercy of the measurers who take them.

Although the variable with the lowest correlation (biacromial diameter) did not present systematic errors, it suffered from repeatability problems (precision error). The results of these and many more studies show how difficult it is to measure humans, even under controlled conditions and after extensive training of the observers.

In image-based systems, the sources of error take the form of perspective distortion, camera resolution, land marking error, and modeling error since circumferences are not measured directly. Thus, the accuracy and precision of measurements made from two-dimensional images of humans, compare them with those of highly trained anthropometrists should be quantified, and the results useful for clothing and equipment sizing.

Meanwhile, the performance of the image processing to the image captured can be influenced by few metrics.

Performance metrics

The quality of a digital image is the sum of various factors, such as pixel count (typically listed in megapixels, millions of pixels) is only one of the major factors. Pixel count metrics were created by the marketing organizations of digital camera manufacturers because consumers can use it to easily compare camera capabilities. It is not, however, the major factor in evaluating a digital camera. The processing system inside the camera that turns the raw data into a color-balanced and pleasing photograph is the most critical like:

- Lens quality**:** resolution, distortion, dispersion
- Capture medium**:** CMOS, CCD, Negative film, Reversal Film etc.
- Capture format**:** pixel count, digital file type (RAW, TIFF, JPEG), film format (135 film, 120 film, 5x4, 10x8).
- Processing**:** digital and / or chemical processing of 'negative' and 'print'.

Some of the factors are discussed below:

1. Pixel Count

The number of pixels *n* for a given maximum resolution (*w* horizontal pixels by *h* vertical pixels) can be found using the formula:

Pixel count, n = wh
Aspect ratio = w/h

The majority of compact (not SLR) digital cameras have a 4:3 (According to *Digital Photography Review*, the 4:3 ratio is because "computer monitors are

4:3 ratio, old CCD's always had a 4:3 ratio, and thus digital cameras inherited this aspect ratio)

Since there are only a very few aspect ratios that are commonly used (4:3 and 3:2), the number of sensor sizes are more limited

More pixels means higher resolution, which creates better image quality because you end up with more realistic representations of color, better gradations of both individual colors and gray tones, and crisper images in general

2. Resolution

Resolution provides an indication of the amount of detail that is captured, but, like the other metrics, resolution is just another factor out of many in determining the quality of an image.

There are several other factors that impact a sensor's resolution. Some of these factors include sensor size, lens quality, and the organization of the pixels

The resolution of a digital camera by the camera sensor (typically a CCD or CMOS chip) turns light into discrete signals, replacing the job of film in traditional photography. The sensor is made up of millions of "buckets" that essentially count the number of photons that strike the sensor. This means that the brighter the image at that point the larger of a value that is read for that pixel. Depending on the physical structure of the sensor a color filter array may be used which requires a demosaicing/interpolation algorithm.

3. Sensors

Sensors read the intensity of light as filtered through different color filters, and digital memory devices store the digital image information, either as RGB color space or as raw data.

There are two main types of sensors:

- Charge-coupled device (CCD) - photocharge is shifted to a central charge-to-voltage converter
- CMOS sensors - Active pixel sensor

4. Dynamic range

Practical imaging systems, digital and film, have a limited dynamic range which can be reproduced accurately. Highlights of the subject which are too bright will be rendered as white, with no detail; shadows which are too dark will be rendered as black. The loss of detail is not abrupt with film, or in dark shadows with digital sensors: some detail is retained as brightness moves out of the dynamic range. "Highlight burn-out" of digital sensors, however, can be abrupt, and highlight detail may be lost. And as the sensor elements for different colors saturate in turn, there can be gross hue shift in burnt-out highlights.

Some digital cameras can show these blown highlights in the image review, allowing the the picture to be re-shoot with a modified exposure. Others compensate for the total contrast of a scene by selectively exposing darker pixels longer. The image sensor contains additional photodiodes of lower sensitivity than the main ones; these retain detail in parts of the image too bright for the main sensor.

High dynamic range imaging (HDR) addresses this issue by increasing the dynamic range of images by either:

- increasing the dynamic range of the image sensor or
- by using exposure bracketing and post-processing the separate images to create a single image with a higher dynamic range.

5. Sensor size and angle of view

Cameras with digital sensors that are smaller than the typical 35mm film size will have a smaller field or angle of view when used with a lens of the same focal length. This is because angle of view is a function of both focal length and the sensor or film size used.

If a sensor smaller than the full-frame 35mm film format is used, such as the use of APS-C-sized digital sensors in DSLRs, then the field of view is cropped by the sensor to smaller than the 35mm full-frame format's field of view. This narrowing of the field of view is often described in terms of a *focal length multliplier* or crop factor, a factor by which a longer focal length lens would be needed to get the same field of view on a full-frame camera.

Most digital cameras, have sensors that are smaller than a standard frame of 35 mm film. These smaller sensors have a number of effects on the captured image and the use of the camera:

- Increased depth of field.
- Decreased light sensitivity and increased pixel noise.
- For digital SLRs, cropping of the field of view when using lenses from a 35 mm camera.
- Increased degree of enlargement.

6. Depth Of Field

Depth of field is the range of distance around the focal plane which is acceptably sharp. The depth of field varies depending on camera type, aperture and focusing distance. The depth of field does not abruptly change from sharp to unsharp, but instead occurs as a gradual transition. In fact, everything immediately in front of or in back of the focusing distance begins to lose sharpness even if this is not perceived by our eyes or by the resolution of the camera.

With the development of VAAMS, two-dimensional, image-based anthropometric measurement systems have replaced the traditional anthropometric tools in applications such as clothing sizing. The system low in cost and measuring task is fast and simple that can determine the cloth sizes. Although the systems appear to be successful but consideration of precision and accuracy for the measurement is important. It was concluded that, when properly designed and calibrated, image-based systems can provide unbiased anthropometric measurements that are quite comparable to traditional measurement methods (performed by skilled measurers) in terms of accuracy and repeatability.

11.0 CONCLUSIONS

From the measureant conduct it is clear that the VAAMS system do have the high reliability in order to measure the land mark on the face at the front side. It indicated by the small error value between true values with VAAMS system value.

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