CRANIOFACIAL ANTHROPOMETRY: MEASUREMENT COMPARISON BETWEEN CONTACT AND NON-CONTACT METHOD

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Abstract

Modelling and measurement of the human face have been increasing by importance for various purposes. One of the purposes is craniofacial anthropometry or human face measurement. This paper is focused on measurement comparison between contact and non-contact method for craniofacial anthropometry. Mannequin is the type of data used in this research. The mannequin are scanned using two laser scanner VIVID910 to create the 3D model. Then the measurement will be made on that 3D model based on landmarks of human face. All the measurements are compared with contact method (caliper and microscribe). The result from this comparison shows which method is more precise.

Keywords: craniofacial, landmarks, comparison

1.0   INTRODUCTION

Craniofacial (or simply human face) is an important part of human anatomy. Human face is a complex surface, with different depth and texture. In craniofacial anthropometry, human faces need to be modelled and measured accurately. Most surgeons are still relying on laborious traditional contact method (for example, calipers) for measuring anthropometric landmarks on human face.

This paper discusses the accuracy between contact (caliper and microscribe) and non-contact method (laser scanner). The instruments used in this papers are shown in Figure 1.

Figure 1. Vernier Caliper, VIVID910 Laser Scanner, Microscribe G2X

VIVID910 laser scanner system uses a laser beam to measure an object, and has the capability to record the whole measurement in a snap (about 0.3 sec (fast mode), 2.5 sec (fine mode), and 0.5 sec (color mode)). There are 3 main advantages of VIVID910, i.e. speed, precision, and simplicity (i.e. point and shoot simplicity for consistently excellent results). The accuracy (Z, typically) of laser scanner are within 0.008 mm using fine mode. VIVID910 employs 3 types of mounted lens, depending on the object sizes and measurement distances. VIVID910 comes with Polygon Editing Tool (PET) software for real time scanning and data processing.

Vernier caliper is a common tool used in laboratories and industries to accurately determine the fraction part of the least count division. The vernier caliper is a convenient tool to use when measuring the length of an object, the outer diameter (OD) of a round or cylindrical object, the inner diameter (ID) of a pipe, and the depth of a hole. The vernier caliper also a conventional tool use by surgeon to take the measurement. This vernier caliper is an extremely precise measuring instrument and its reading error is 0.05 mm.

Microscribe G2X is a portable 3D digitizing system and it equipped with the mechanical arm. The mechanical arm is carefully counterbalanced and equipped with precision bearings for smooth, effortless manipulation. Each joint uses digital optical sensors, which are immune from any environmental noise and interference. It all makes for a versatile system that can work in almost any environment and be used with objects of any material. The MicroScribe G2X has the accuracy up to 0.009" (0.23mm). The Microscribe G2X also can work with variety of software such as Rhinoceros, AutoCAD, SoftImage, Microsoft Excel, and others.

2.0   METHOD

As discussed in section 1, the following instruments were used in order to make a measurement comparison within two methods: non-contact (laser scanner VIVID910) and contact (Vernier Caliper and Microscribe G2X).

The mannequin was mark with the craniofacial landmarks (Figure 2) on it surface to make the digitizing process much easier. A total 40 point of craniofacial landmarks was mark on the mannequin surface.
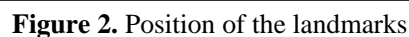

Figure 2. Position of the landmarks

Table 1. Summary of Landmarks Definition on Craniofacial Surface

No	Landmark name	Initial	Description
1	Frontotemporale	ft	The most medial point on the temporal crest of the frontal bone
2	Frontozygomaticus	fz	The most lateral point on the frontozygomatic suture
3	Glabella	g	The most prominent point in the median sagital plane between the supraorbital ridges
4	Tragion	t	Located at the notch above the tragus of the ear, the cartilaginous projection in the front of the external auditory canal, where the upper edge of the cartilage disappears into the skin of the face
5	Trichion	tr	Midpoint of the hairline
6	Condylion laterale	cdl	The most lateral point on the mandibular condyle
7	Gonion	go	The most lateral point at the angle of the mandible
8	Nasion	n	The midpoint of the nasofrontal suture
9	Pogonion	pg	The most anterior point in the middle of the soft tissue chin
10	Sublabiale	sl	The midpoint of the labiomental sulcus
11	Subnasale	sn	The junction between the lower border of the nasal septum, the partition which divides the nostrils, and the cutaneous portion of the upper lip in the midline
12	Zygion	zy	The most lateral point on the zygomatic arch
13	Endochantion	en	The inner corner of the eye fissure where the eyelids meet, not the caruncles (the red eminences at the medial angles of the eyes)
14	Exochantian	ex	The outer corner of the eye fissure where the eyelids meet
15	Orbitale	or	The lowest point on the margin of the orbit
16	Orbitale superius	os	The highest point on the margin of the orbit
17	Alar curvature	ac	The most posterolateral point of the curvature of the base of the nasal alae, the lateral flaring walls of the nostrils
18	Pronasale	prn	The most protruded point of the nasal tip
19	Subalare	sbal	The point on the lower margin of the base of the nasal ala where the ala disappears into the upper lip skin
20	Cheilion	ch	The outer corner of the mouth where the outer edges of the upper and lower vermilions meet
21	Labial superius	ls	The midpoint of the vermilion border of the upper lip
22	Labiale superius lateralis	ls'	The point on the upper vermilion border directly inferior to subalare (sbal)
23	Otobasion inferius	obi	The lowest point of attachment of the external ear to the head
24	Otobasion superius	obs	The highest point of attachment of the external ear to the head

Then the mannequin was scanned using two laser scanners with one scanner cover the right side and the other scanner cover the left side. The angle of intersection for this two scanner is 90^0 on the centre of mannequin surface. During the scanning process, Polygon Editing Tools (P.E.T) software was used to handle the data capturing process. Then the scanned data was saved in .cdm file in order to transfer it to Rapidform2004 software. Rapidform software is used for 3D modelling of mannequin. Figure 3 show the generated 3D model in Rapidform software. The craniofacial landmarks was digitized manually on the 3D model of mannequin using Rapidform. From this 40 craniofacial landmarks, 41 measurements between two landmarks were made.

In this paper, Microsoft Excel is used with Microscribe G2X to obtain the coordinate (x,y,z) of each landmarks on the mannequin. The 3D coordinate of each landmarks was obtain manually with physical contact of microscribe mechanical arm tip onto the surface of mannequin. Then the 3D coordinate for each landmarks will appear in Microsoft Excel and from this 3D coordinate, the measurements were made using Microsoft Excel.
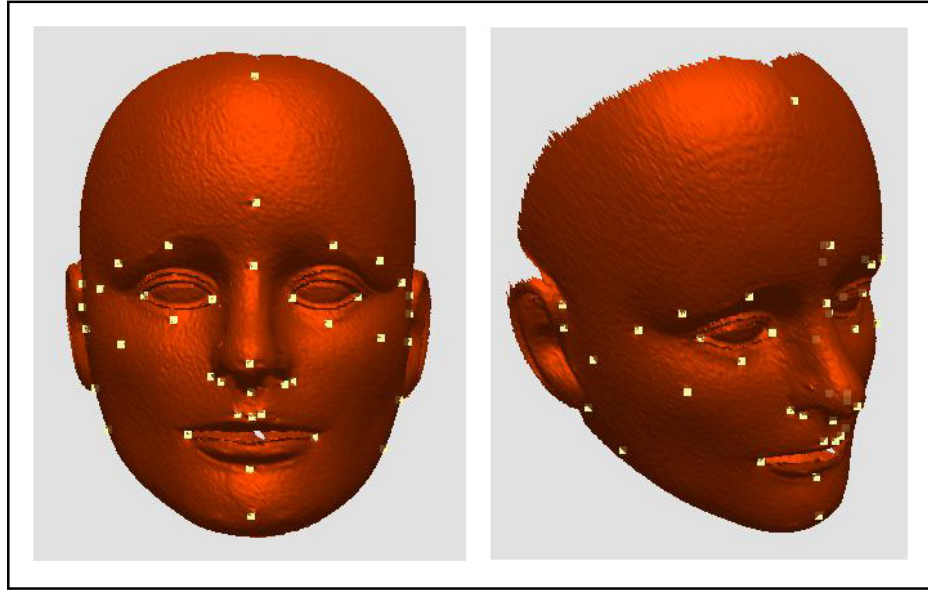
Figure 3. 3D Model of Mannequin

3.0 RESULTS AND ANALYSIS

In this paper, each instrument measured the same mannequin for 10 times and the caliper was used as a standard. Table 2 show mean and standard deviation for each instrument.

Comparison of the measurement on a mannequin between the caliper, microscribe and laser scanner are shown in Table 3. The differences between caliper vs. microscribe (difference 1 in Table 3) are between (–0.497 mm to 0.694mm), caliper vs. laser scanner (difference 2 in Table 3) and microscribe vs. laser scanner (difference 3 in Table 3) are between (–0.669mm to 0.742mm) and (–1.245mm to 0.426mm) respectively.

Table 2. Mean and Standard Deviation

No	Measurement	Mean			Standard Deviation		
		Caliper	Microscribe	Laser Scanner	Caliper	Microscribe	Laser Scanner
1	ftR - ftL	93.955	93.502	94.246	0.096	0.185	0.189
2	tr - g	50.740	51.051	51.052	0.102	0.192	0.196
3	tr - n	70.865	71.362	71.034	0.088	0.237	0.242
4	fzR - fzL	112.660	112.522	112.748	0.077	0.284	0.179
5	fzR - g	73.455	73.208	73.267	0.090	0.388	0.187
6	fzL - g	71.960	71.485	71.218	0.081	0.334	0.114
7	zyR - zyL	93.340	92.782	93.302	0.077	0.327	0.371
8	goR - goL	107.225	107.145	107.252	0.079	0.230	0.251
9	g - tR	102.445	101.979	102.610	0.086	0.399	0.188
10	g - tL	101.350	100.852	101.241	0.100	0.361	0.295
11	n - tR	96.175	95.758	96.606	0.103	0.302	0.193
12	n - tL	94.955	94.375	94.869	0.130	0.425	0.287
13	exR - tR	54.305	54.388	54.325	0.098	0.308	0.348
14	exL - tL	55.515	54.939	56.184	0.103	0.346	0.293

15	sn - tR	104.270	104.528	104.103	0.155	0.233	0.203
16	sn - tL	102.330	101.79	102.860	0.086	0.252	0.244
17	exR - goR	61.570	60.913	60.873	0.216	0.214	0.327
18	exL - goL	66.220	65.655	66.340	0.187	0.295	0.531
19	goR - cdlR	39.610	39.659	39.851	0.074	0.154	0.277
20	goL - cdlL	41.880	42.008	42.201	0.132	0.133	0.255
21	g - sn	64.485	64.714	64.811	0.142	0.217	0.115
22	sn - pg	42.795	42.845	42.846	0.069	0.116	0.425
23	sl - pg	16.110	16.095	15.753	0.052	0.140	0.312
24	g - pg	106.510	106.830	107.004	0.105	0.203	0.426
25	enR - enL	27.620	26.926	27.645	0.089	0.335	0.251
26	exR - exL	76.765	76.430	76.916	0.142	0.266	0.403
27	enR - exR	26.380	26.275	26.676	0.142	0.312	0.280
28	enL - exL	24.955	25.301	25.185	0.150	0.282	0.344
29	sbalR - sn	11.425	11.339	11.278	0.153	0.191	0.237
30	sbalL - sn	12.820	12.497	12.367	0.144	0.179	0.207
31	sn - prn	15.935	15.475	15.954	0.125	0.101	0.183
32	acR - prn	24.405	24.276	24.539	0.083	0.266	0.601
33	acL - prn	26.020	25.547	25.914	0.071	0.242	0.234
34	n - sn	43.225	43.274	43.611	0.130	0.352	0.287
35	n - prn	38.000	37.915	38.133	0.168	0.292	0.356
36	chR - chL	44.250	43.940	43.978	0.113	0.223	0.262
37	sn - ls	8.380	8.517	8.479	0.086	0.138	0.162
38	sbalR - lsR	13.090	12.959	13.160	0.074	0.281	0.161
39	sbalL - lsL	13.665	13.583	13.409	0.067	0.211	0.221
40	obsR - obiR	42.190	42.150	42.594	0.066	0.213	0.192
41	obsL - obiL	42.165	42.361	42.325	0.078	0.171	0.114

Table 3. Comparison of Results

No	Measurement	Caliper [A]	Microscribe [B]	Laser Scanner [C]	Diff 1 [A – B]	Diff 2 [A – C]	Diff 3 [B – C]
1	ftR - ftL	93.955	93.502	94.246	0.453	-0.291	-0.743
2	tr - g	50.740	51.051	51.052	-0.311	-0.312	-0.002
3	tr - n	70.865	71.362	71.034	-0.497	-0.169	0.329
4	fzR - fzL	112.660	112.522	112.748	0.138	-0.088	-0.225
5	fzR - g	73.455	73.208	73.267	0.247	0.188	-0.059
6	fzL - g	71.960	71.485	71.218	0.475	0.742	0.267
7	zyR - zyL	93.340	92.782	93.302	0.558	0.038	-0.520
8	goR - goL	107.225	107.145	107.252	0.080	-0.026	-0.106
9	g - tR	102.445	101.979	102.610	0.466	-0.165	-0.631
10	g - tL	101.350	100.852	101.241	0.498	0.109	-0.389
11	n - tR	96.175	95.758	96.606	0.417	-0.431	-0.847
12	n - tL	94.955	94.375	94.869	0.580	0.086	-0.495
13	exR - tR	54.305	54.388	54.325	-0.083	-0.020	0.062
14	exL - tL	55.515	54.939	56.184	0.576	-0.669	-1.245
15	sn - tR	104.270	104.528	104.103	-0.258	0.167	0.426
16	sn - tL	102.330	101.79	102.860	0.540	-0.530	-1.071
17	exR - goR	61.570	60.913	60.873	0.657	0.697	0.040
18	exL - goL	66.220	65.655	66.340	0.565	-0.120	-0.685
19	goR - cdlR	39.610	39.659	39.851	-0.049	-0.241	-0.192

20	goL - cdlL	41.880	42.008	42.201	-0.128	-0.321	-0.194
21	g - sn	64.485	64.714	64.811	-0.229	-0.326	-0.097
22	sn - pg	42.795	42.845	42.846	-0.050	-0.051	-0.001
23	sl - pg	16.110	16.095	15.753	0.015	0.357	0.341
24	g - pg	106.510	106.830	107.004	-0.320	-0.494	-0.175
25	enR - enL	27.620	26.926	27.645	0.694	-0.025	-0.719
26	exR - exL	76.765	76.430	76.916	0.335	-0.151	-0.485
27	enR - exR	26.380	26.275	26.676	0.105	-0.296	-0.401
28	enL - exL	24.955	25.301	25.185	-0.346	-0.230	0.116
29	sbalR - sn	11.425	11.339	11.278	0.086	0.147	0.061
30	sbalL - sn	12.820	12.497	12.367	0.323	0.453	0.130
31	sn - prn	15.935	15.475	15.954	0.460	-0.019	-0.479
32	acR - prn	24.405	24.276	24.539	0.129	-0.134	-0.263
33	acL - prn	26.020	25.547	25.914	0.473	0.106	-0.367
34	n - sn	43.225	43.274	43.611	-0.049	-0.386	-0.337
35	n - prn	38.000	37.915	38.133	0.085	-0.133	-0.218
36	chR - chL	44.250	43.940	43.978	0.310	0.273	-0.037
37	sn - ls	8.380	8.517	8.479	-0.137	-0.099	0.039
38	sbalR - lsR	13.090	12.959	13.160	0.131	-0.070	-0.201
39	sbalL - lsL	13.665	13.583	13.409	0.082	0.256	0.174
40	obsR - obiR	42.190	42.150	42.594	0.040	-0.404	-0.443
41	obsL - obiL	42.165	42.361	42.325	-0.196	-0.160	0.037

4.0   CONCLUSION

This paper discusses the comparison tests on measurement for craniofacial anthropometry using contact (Vernier Caliper and Microscribe G2X) and non-contact method (VIVID910 laser scanning). The results show the differences between each instrument within sub-mm. The outcome from this paper shows the suitability of laser scanning techniques for craniofacial anthropometry.

5.0   ACKNOWLEDGEMENT

6.0   REFERENCES

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