

The Development of Image Capturing System and Information System for Craniofacial Reconstruction

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SUMMARY

A multi-disciplinary research is established between Universiti Teknologi Malaysia (UTM), Standards & Industrial Research Institute Malaysia (SIRIM), and Universiti Sains Malaysia (USM). The research focuses on the development of surgical planning system for craniofacial reconstruction, for both the soft and hard tissues. This paper discusses the research works undertaken by UTM, especially on the development of a close range image capturing system and information system for craniofacial. The image capturing system combines the laser scanning and photogrammetric techniques for acquiring high-resolution 3D models of craniofacial soft tissue. The resulted 3D models are processed and combined with other relevant data (such as hard tissue, measurement, and patient's information) for the development of nation-wide database for normal and malformation craniofacial. The information system is used for managing and visualizing the craniofacial data. Preliminary results are also included to highlight the developed approach.

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1. INTRODUCTION

Craniofacial (or simply human face) is an important part of human anatomy. Human face is a complex surface, with different depth and texture (Figure 1). For medical purposes (such as craniofacial reconstruction), human faces need to be modeled and measured accurately. Our preliminary research indicated that most surgeons (in Malaysia) are still relying on laborious traditional contact method (for example, calipers) for measuring anthropometric landmarks on human face.

Consequently, a multi-disciplinary research is established between Universiti Teknologi Malaysia (UTM), Standards & Industrial Research Institute Malaysia (SIRIM), and Universiti Sains Malaysia (USM). The research focuses on the development of surgical planning system for craniofacial reconstruction, for both the soft and hard tissues.

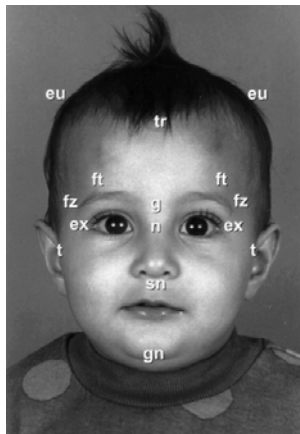


Figure 1: Human face and anthropometric landmarks

2. METHOD

This paper discusses the research works undertaken by UTM (Figure 2), especially on the development of a close range image capturing system (blue colored in Figure 2) and information system (yellow colored in Figure 2) for craniofacial soft tissue.

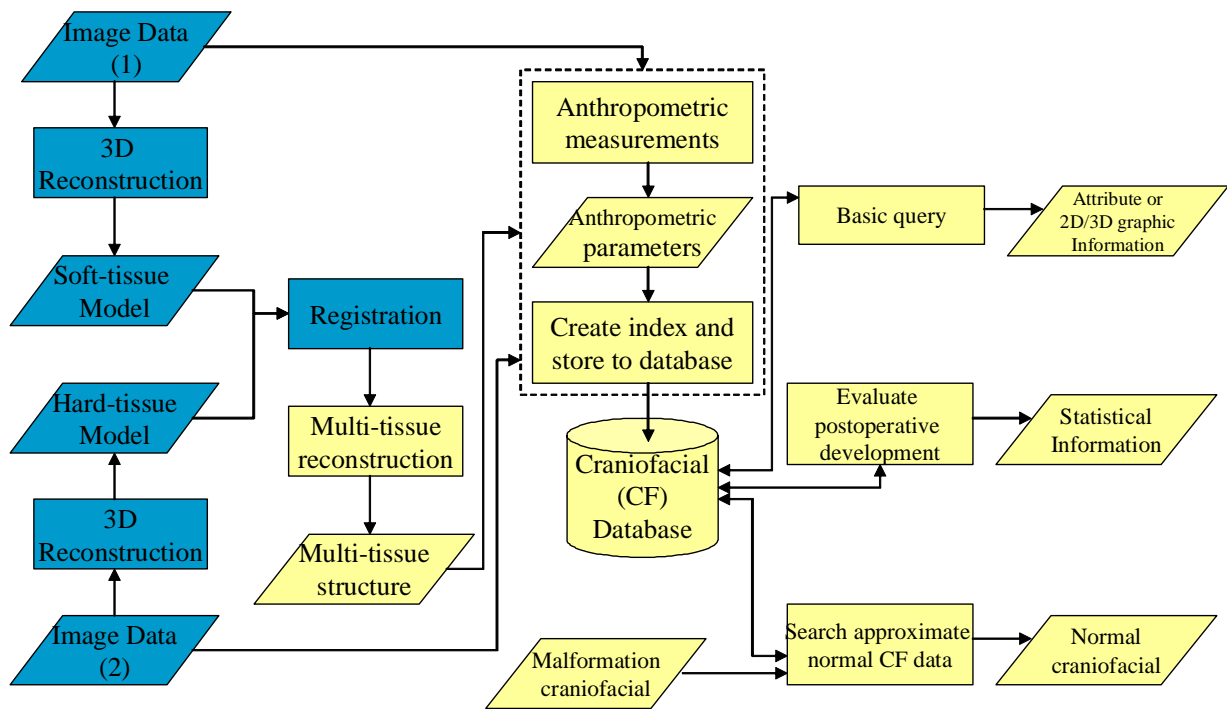


Figure 2: The method for capturing (in blue) and information (in yellow) systems

The developed image capturing system (Figure 3 and Figure 4) combines the laser scanning using Minolta Vivid 910 (L1, L2) and stereo photogrammetric (C1, C2, C3) techniques for acquiring high-resolution 3D models of craniofacial soft tissue (Zulkepli et al, 2004). The combination provides advantages in terms of rapid 3D modeling (via laser scanning) and precise measurement (via photogrammetric) (Halim & Mohd Sharuddin, 2004).

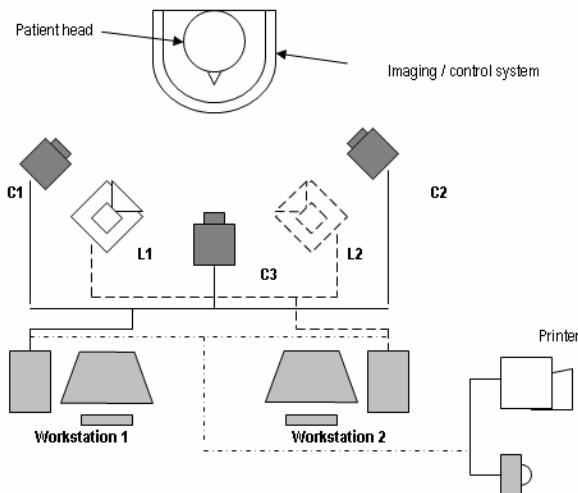


Figure 3: The image capturing system

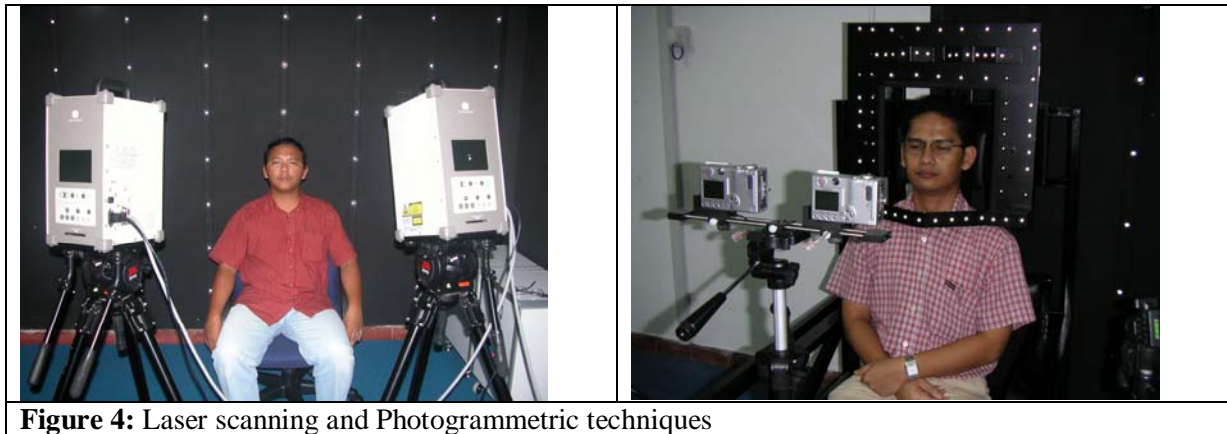


Figure 4: Laser scanning and Photogrammetric techniques

The resulted 3D soft tissue models are processed and combined with other relevant data (such as 3D hard tissue model from CT scan, measurement, and patient's information) for the development of an information system (Figure 2) for managing and visualizing the craniofacial data (i.e. a nation-wide database for normal and malformation craniofacial).

3. RESULTS

The collected data from scanner and photogrammetric are processed using Polygon Editing Tool (PET) and Digital Video Plotter (DVP) software respectively. In addition, Rapidform software is used for 3D modeling of human faces. Figure 5 and Figure 6 show the generated 3D models and measurement results. Comparison of the measurement on a mannequin between the caliper (used as standard), photogrammetry and laser scanner are shown in Table 1 (M. Farid et al, 2004). The differences between photogrammetry vs caliper [difference 1 in Table 1) and laser scanner vs caliper [difference 2 in Table 1) are between (-2.9mm to 1.7mm) and (-3.2mm to 2.0mm) respectively. Moreover, the differences between laser scanner vs photogrammetry [difference 3 in Table 1) are (-1.6mm to 4.9mm). These preliminary results show the differences within few mm, and mainly due to the inaccuracies of locating the anthropometric landmarks either manually (using caliper) or digitally (using DVP and RAPIDFORM).

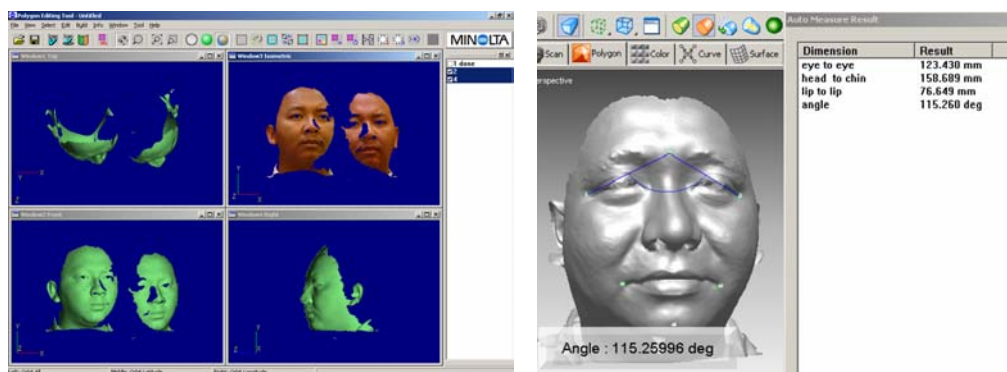


Figure 5: Results in PET and RAPIDFORM

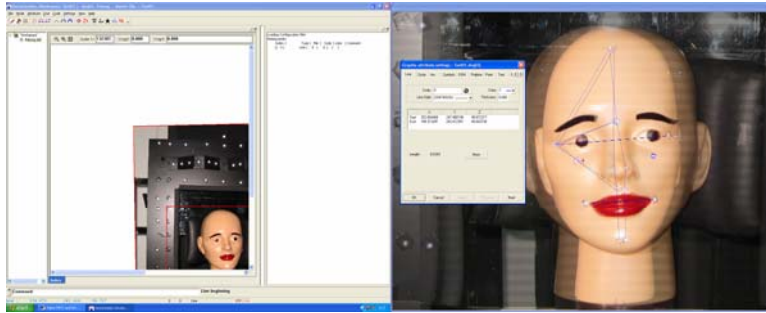


Figure 6: Results in DVP

Measurement Points	Calipers [A] +/- 0.05 (mm)	Photo [B] (mm)	Laser [C] (mm)	Diff 1 [B-A] (mm)	Diff 2 [C-A] (mm)	Diff 3 [C-B] (mm)
1 ~ 2	96.55	98.26	97.43	1.71	0.88	-0.83
6 ~ 7	60.25	58.68	57.08	-1.57	-3.17	-1.60
10 ~ 11	62.65	63.64	63.50	0.99	0.85	-0.14
4 ~ 3	63.90	61.04	65.94	-2.86	2.04	4.90
3 ~ 9	43.10	41.05	44.05	-2.05	0.95	3.00
1 ~ 3	56.70	54.96	58.52	-1.74	1.82	3.56
2 ~ 3	55.40	54.32	55.88	-1.08	0.48	1.56
10 ~ 3	45.30	44.40	46.40	-0.90	1.10	2.00
11 ~ 3	42.95	41.92	42.15	-1.03	-0.80	0.23
9 ~ 5	20.90	19.80	20.98	-1.10	0.08	1.18

Table 1: Comparison of results

In this research, an experimental prototype information system is developed using the extensibility features of the PostgreSQL object-relational database management system (ORDBMS) developed at the University of California at Berkeley Computer Science Department. The prototype (Figure 7) has a client/server architecture, with Borland Delphi package as the tool for developing an interactive, query front-end application (Deni et al, 2004).

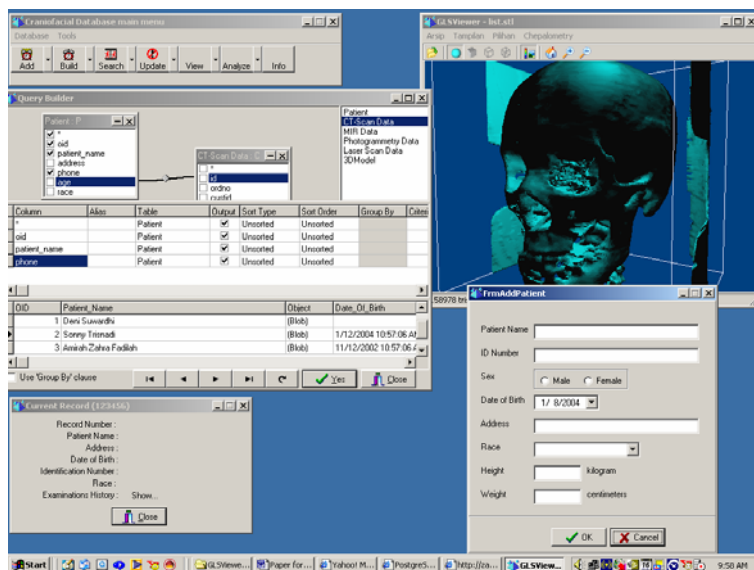


Figure 7: The prototype information system

4. CONCLUSIONS

A multi-disciplinary research is established between Universiti Teknologi Malaysia (UTM), Standards & Industrial Research Institute Malaysia (SIRIM), and Universiti Sains Malaysia (USM). The research focuses on the development of surgical planning system for craniofacial reconstruction, for both the soft and hard tissues.

This paper discusses the research works on the development of a close range image capturing system and information system for craniofacial. The image capturing system combines the laser scanning and photogrammetric techniques for acquiring high-resolution 3D models of craniofacial soft tissue. The information system is used for managing and visualizing the craniofacial data.

The resulted 3D models are processed and combined with other relevant data (such as hard tissue, measurement, and patient's information) for the development of nation-wide database for normal and malformation craniofacial.

ACKNOWLEDGEMENT

This research is part of a prioritised research IRPA Vot 74537 sponsored by Ministry of Science, Technology & Innovation (MOSTI), Malaysia.

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