APPLICATION OF CLOSE RANGE PHOTOGRAMMETRY IN THE STUDY OF THE DEVELOPMENT OF HUMAN DENTAL AND JAWS

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ABSTRACT

Branch of science related to health and medicine are in need of high accuracy. One application that combines the medical field and geodesy is monitoring the growth and development of jaws and teeth using Close Range Photogrammetric method. Points to consider in monitoring the development of teeth and jaws are the number of teeth, tooth shape and size of teeth that interfere with the function. In addition to health, monitoring is also useful for aesthetic aspects. Monitoring the growth of jaws and teeth allow for early handling problems that are there on the jaw and teeth. The more accurate measurement, the better treatment can be done. Because it needed a method to obtain accurate measurements from the jaw and teeth, then Close Range of Photogrammetric method is considered.

1. INTRODUCTION

Currently, the science of Geodesy and Geomatics not only applied on topographic mapping alone, but the basis of all studies that are based on positioning. In connection with the study, then it not only limited to the objects of the earth (land and sea) or air. Positioning is not associated with topographic mapping known as Non Topographical Mapping. One method in Non Topographic Mapping which is often used is Close Range Photogrammetric (CRP). Close Range Photogrammetric also has a very broad potential application. Close Range Photogrammetric is able to produce three dimensional model (3D) objects to the size of which is the result of careful reconstruction of the photographs that are two dimensional (2D), the observation of the object in this project will be studied and tested the application of CRP to medical science.

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FIGURE 1 DENTAL TREATMENT

Monitoring the development of jaws is commonly using a simple comparison between twin models from one patient after and before treatment done. Measuring instruments used are ruler, vernier and a thread. Geodesy and Geometry field of science makes it possible to get the data with a precision that can be determined in accordance with the usefulness of the data in the future. Thus, the data with precision and higher accuracy can be obtained by using the Close Range Photogrammetric method. The process of matching and comparing can be done more quickly.

2. METHODOLOGI

In this work the principle of close range photogrammetric will be used to get the 3D model of the Dental Cast one patient before treatment and after treatment. All of the spatial coordinates that have been obtained will be processed in software to form the surface model of the object (mesh of triangular polygons). The camera used in this modeling is Nikon D60 with Nikon Lens 35mm fix.

FIGURE 2 NIKON D60

TABLE 1 NIKON D60 SPECIFICATION

Censor	CCD Censor
Censor size	23.6x15.8 mm
Pixel size	3873x2592
Maximum Aperture	f/1.8
Minimum Aperture	f/22

Close Range Photogrammetric software used in this work is Australis 7 for the calibration of camera and Photomodeller Scanner for 3D modeling. Camera calibration performed in Australis 7 because the results obtained are more stable than the results in Photomodeller Scanner. Photomodeller scanner device is used to get the surface model of the object.

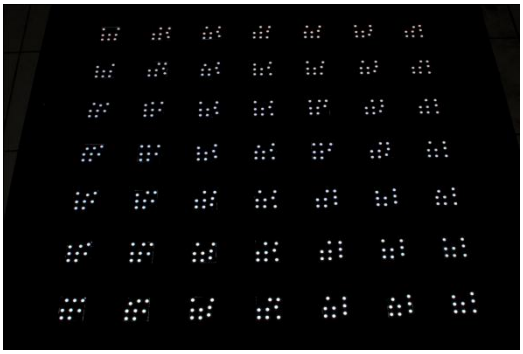

FIGURE 3 CALIBRATION PANEL

Bundle adjustment used to generate external orientation parameters and spatial coordinates of control points. This process requires the photographs of the object which is the object that 3D model will be created with and control points that shall be determined its spatial coordinates. There are minimum 8 exposures of photos required in this process. The position of the image making is in accordance with 8 cardinal directions. Photo is taken using Nikon D60 camera with 3872x2592 pixel image size. Control points that are used are Coded Target 12-bit. The spread of coded targets also adding the elevation factor so the details will be better in terms of contours. Here are examples of Dental Cast photo shoot that has been done:

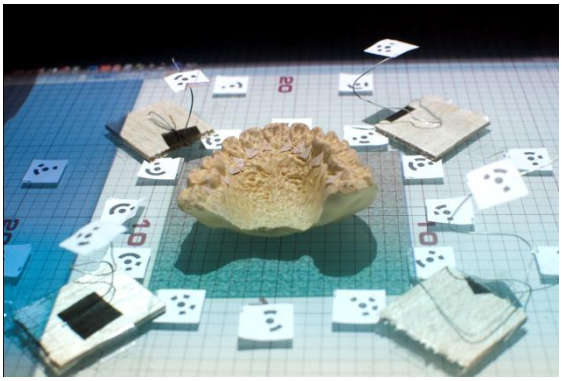

FIGURE 4 PHOTO SHOOT RESULT

The object used is Dental Cast with no patterns and can almost be considered a homogeneous surface. These causes Point Mesh produced very little and cannot represent the entire surface that is required. The solution is to use a projector that can display the pattern to the object.

FIGURE 5 PATTERNS

FIGURE 6 PROJECTOR PLACEMENTS

Photo shoot is done with a tripod to get good image stability. The format for storing pictures as well as calibration and data acquisition is RAW (.NEF). It is used to avoid any compression on the photo so it will possibly remove some particular informations in the format such as .JPEG. By using the camera calibration and orientation for all images, Photomodeller Scanner does all the leveling process and bundle adjustment in all tie points. After the bundle adjustment was done, using the external orientation parameters that had been obtained, 3D model of the object (Dental Cast) is obtained.

3. RESULTS AND ANALYSIS

Calibration results obtained from the calibration panel image capture as much as 5 series with each series has 8 position in taking pictures. Parameter calibration of the five series data then were averaged to obtain the calibration parameters to be used for further processing in Photomodeller Scanner. The stability of the five series of data was measured with t-student test, in order to obtain that the difference of the five series of data is not significant. The results of calibration parameters can be seen in Table 2.

TABLE 2 CALIBRATION PARAMETERS

f	36.52 mm
Xp	0.022 mm
Yp	0.0185 mm
K1	0.000124
K2	1.4E-07
K3	-6.3E-10
P1	-3E-06
P2	2.41E-05

In the experiment and this research the result obtained from manual processes in the field and 3D modeling will be compared.

3D Modeling

Bundle Adjustment is performed using Photomodeller Scanner software with the largest residual value is 0.8712 pixels with an average RMS value for the control points of 0.397 pixels and the average angle of 76.84°. For precision X,Y, and Z can be seen in Table 3 while the results of 3D modeling can be seen in Figure 7.

TABLE 3 RMS FOR X,Y AND Z

RMS x	0.002329 mm
RMS y	0.003392 mm
RMS z	0.002457 mm

FIGURE 7 3D MODELLING

The results of this 3D model are checked with the distance in the model against distance in field. The process is carried out on two distance constraint in the model with distance in field. Measurements were taken with five distances with two of them were used in constraint and the rest used for checking.

TABLE 4 COMPARISONS OF DISTANCES

No	Distance in field (cm)	Distance in model (cm)	Difference
1	9.9	9.9	0
2	14	13.969	0.031
3	11.3	11.357	0.057
4	5.7	5.646	0.054
5	5.7	5.667	0.033

From table above can be seen the biggest difference is 0.57 mm. Accuracy of this already represents a good precision of the results of the Dental Cast object modeling.

Manual Measurement Method vs. Landmark Method

Manual measurements performed by using a ruler, vernier and a thread. Dental arch measurements performed with a term for each tooth segment starting from the first molar tooth right to left first molar tooth. One segment consists of two gear teeth, as follows :

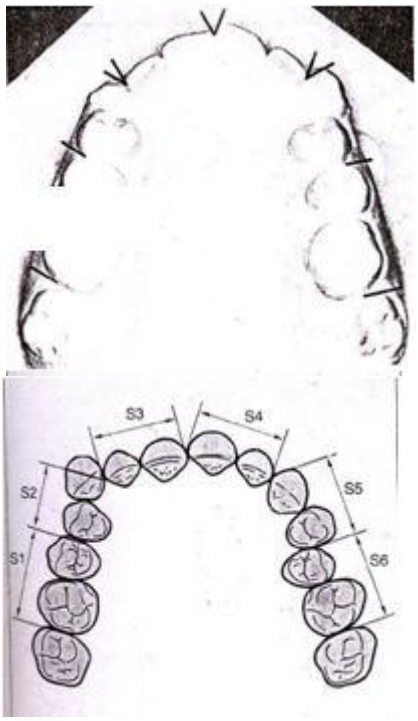

FIGURE 8 SEGMENTS ON TEETH

This is done to see differences between jaw arch and teeth arch for treatment which is matching this two size. Because the modeling was done for post-treatment dental object, then the results obtained for jaw arch and teeth arch is not too different from one another. For the landmarks, double-sided tape is used and it affixed to dental cast and then uses it as tie points in the software.

TABLE 5 TEETH ARCH COMPARISON

Segment	Width on manual method (cm)	Width on software (landmark) (cm)
S1	2.25	2.244
S2	1.6	1.500
S3	1.4	1.480
S4	1.4	1.478
S5	1.6	1.590
S6	1.8	1.886
Total	10.15	10.178

TABLE 6 JAW ARCH COMPARISON

Width on field with manual method (cm)	Width on software (Landmark) (cm)
10	10.106

From both tables above it can be seen that the size of jaw arch and teeth arch is almost the same due to dental cast used already passed the process of treatment. But the point that should be emphasized here is that measurement using CRP appear to have fewer difference between teeth arch and jaw arch which is 0.072 cm as for the manual measurements it differs by 0.15 cm.

4. CONCLUSION

Research of the development of jaws and teeth through the measurement of jaw and teeth arc using Close Range Photogrammetric method proved more effective than manual methods using ruler, vernier and a thread. This can be seen from the precision obtained. For Close Range Photogrammetric accuracy value obtained from resultant of x, y and z RMS which is 0.04 accuracy points, while for a ruler is half the size of the smallest measure which is 0.5 mm. They are significant differences from it thoroughness size. CRP method has also proven to be cheaper and its data collection doesnôt take long to acquire.

Tie Points (Landmark points) that are used in the dental cast for Close Range Photogrammetric is seven pieces scattered in every segment of the tooth, as already shown in Figure 8.

To strengthen this conclusion, modeling and measurement of mandible post-treatment as well as upper and lower jaws in the pre-treatment will be done so that the development before and after treatment can be seen.

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