

THREE DIMENSIONAL DATA EXTRACTION FROM RADIOGRAPHS

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ABSTRACT:

The aim of the study is to produce three dimensional (3D) data from radiographs using photogrammetric techniques. Photogrammetry is defined as the process of measurement on an object's images taken in accordance with certain rules instead of direct measurements on the object. This term includes whole operations of taking, processing, analyzing and evaluating the image. Most important advantage of this method in medical studies is the high accuracy and cost effectiveness compared to classical methods. Thus, this study is a photogrammetric approach to medical research and applications.

1. INTRODUCTION

For performing measurements on three dimensional models, stereo X-Ray photogrammetry is a distinct approach. X-Ray photogrammetry is based on central projection of X-Rays that come from the focal point and fall on the film after passing through the object. X-Ray techniques are commonly used in medical sciences and industry. It enables us to get physical data from the human body or a live object and to produce three dimensional images by using this data. By the help of this imaging technique; tumor, cancer, other abnormal activities, harmful unknown pieces like metal pieces in the stomach or other metal pieces as a result of injuries and positional changes and changes in the lengths of broken bones can be accurately measured. For Stereo X-Ray photogrammetry two X-Ray images with 50% or more overlap is required. Then these images are observed in stereo and in order to regenerate the object optically and mathematically, measurements are made on points taken from different positions on the object (Ege et al., 2004; Malian and Heuvel, 2004; Everine et al, 2005).

There are a few mathematical models used in X-Ray photogrammetry. Main aim of these models is to determine the positions of object points in a coordinates system. These operations are done with basic geometrical correlations and calibrations. Main mathematical models used in applications of X-Ray photogrammetry are the Seattle, Cleveland and Direct Linear Transformation (DLT) Model (Toz, 1987; Goktepe, 2004).

This study was conducted to incorporate photogrammetric approach into medical sciences, where analyze and modeling of bones were selected. The radiographs of forearm bones (ulna and radius) have been taken using X-ray technology. During this process, bones were nested into a specially designed and produced mold in order to establish the relationship between image and the object. Then, the radiographs have been scanned and digitized. Three dimensional object coordinates were obtained from picture (pixel) coordinates by means of DLT method. With these object coordinates, the digital three dimensional model of the bone was produced. The coordinates of the control points, which were located on the mold, have

been recalculated by means of DLT method and then compared with the model coordinates. Points and their locations have been calculated and the 3-Dimensional model accuracy was checked. The final product is a 3-Dimensional model, where accurate measurements can be performed, visually understandable and easily interpretable.

2. METHODOLOGY & RESULTS

A three dimensional mold was designed. The mold is a form of box, which is made of plastic and a wood cover to protect the system. The designed mold is establishing the reference system and a coordinate base. The coordinate system surrounds the arm bones (ulna and radius) and 63 points with known coordinates are marked on the mold. 33 of these points have been positioned at the lower base, which is forming a grid. The remaining points were positioned asymmetrically on the right and left sides of the lower base, which is like a ladder structure, illustrated in Figure 1 and Figure 2. Thus, a three dimensional coordinate system was formed to surround the arm bones. Ergonomics of the human arm is also considered while designing the model. Thus, an ergonomic external box was designed to put the arm during the measurement process which also contains coordinates and prevents harms (Birgin, 2007).



Figure 1. The Developed System



Figure 2. Cover of the Developed System

The mechanism to take X-Ray images was positioned on the roentgen device with the height of 89cm from the film level and at least 50% overlapping images were taken. The roentgen device creates the image not behind the object (negative image) like traditional photogrammetric cameras but it is shown at the front of the object (positive image). Due to the positive image, camera focal distance cannot be exactly known and anode tube source cannot be fixed. It was not possible to measure the base distance between two anodes with the desired accuracy. Additionally, the mathematical models used in current photogrammetric software are based on perspective projection rule. Considering all these unknown parameters, the evaluation process has been done with Direct Linear Transformation (DLT) method. DLT method is used for converting image coordinates into object coordinates directly. The most important advantage of this system is the fact that it doesn't require a calibrated camera or marked signs. Thus, software with a mathematical model based on DLT method has been used (Birgin, 2007).

In order to transmit the radiographs to digital environment, a scanning procedure should be utilized. The radiographs with thickness of 120μ to 250μ are scanned in tiff format with 300dpi resolution by using a scanner capable of scanning negative images in A3 format dimensions, shown in Figure 3 and Figure 4.

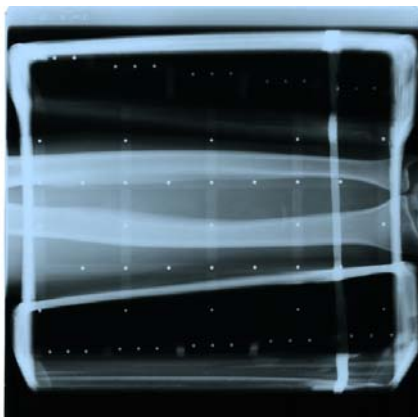


Figure 3. The Radiograph of the left arm

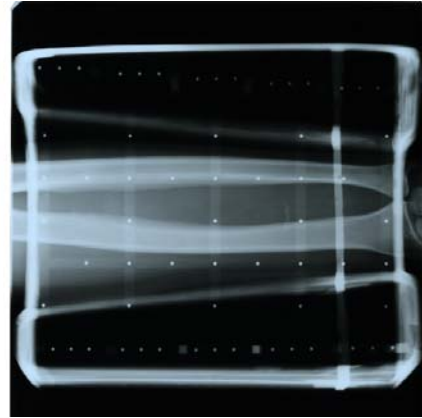


Figure 4. The Radiograph of the right arm

Pixel coordinates of scanned X-Ray films are measured with Adobe Photoshop CS2 software. This software takes the upper left corner of the screen as the origin. Right and left image parameters were found by evaluating the pixel coordinates of the retrieved points with DLT method. Then, pixel coordinate readings of conjugate points on the bones in right and left films were done with Adobe Photoshop CS2 software, Figure 5.

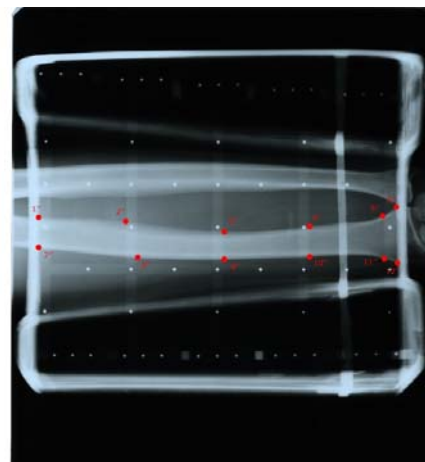
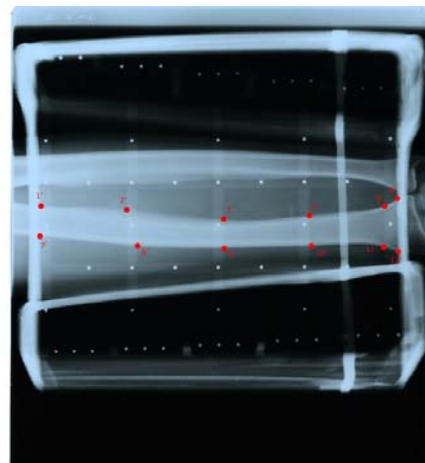


Figure 5. Left and right hand films with conjugate points

As a result of the solution of picture parameters with pixel coordinates retrieved from the points on the bone, the object

coordinates of these points were found. The retrieved coordinates were evaluated in CAD software to find the image of the bone model, illustrated in Figure 6.



Figure 6. 2D drawing of obtained data in CAD

The X, Y, Z coordinates of the randomly chosen twenty control points and X_h , Y_h , Z_h values of the object were computed by DLT method in order to find the correction values. The root mean square for X, Y, Z coordinates, being m_x , m_y , m_z , was computed, where the positional accuracy was $m_p=0.472\text{cm}$. The achieved point accuracy is adequate according to the literature. Factors affecting this accuracy level can be listed as: the structure of the radiograph, precision of the 3D Printer that produced the designed mold, errors stemmed from pixel size due to scanning process with 300dpi. Proposals such as; to scan images at high resolution, to use digital roentgen films and to produce the designed mold at high precision can be used in order to increase accuracy achieved from the study.

3. CONCLUSION

The obtained results indicate the success of the photogrammetric methods on producing 3D models. Visualization of the 3D model is the main advantage of the followed method. 3D images produced with this system will

enhance diagnosis process of the medical doctors, which will enable them to use their experience, knowledge and skills better and faster. In addition to help the diagnosis process, the approach and designed system of producing 3D images can also be used in many other medical areas.

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