BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LXI (LXV), Fasc. 3, 2015
Secţia
CONSTRUCŢII DE MAŞINI

FABRICATION OF A COSMETIC PROSTHESIS USING 3D SCANING AND 3D PRINTING

BY

OCTAVIAN CIOBANU[1*], **GABRIELA CIOBANU**[2] and A**NCA ALEXA**[1]
[1] “Grigore T. Popa” University of Medicine and Pharmacy, Faculty of Medical Bioengineering
[2] “Gheorghe Asachi” Technical University of Iaşi,
Faculty of Chemical Engineering and Environmental Protection

Received: July 15, 2015
Accepted for publication: October, 2015

Abstract. Passive prostheses are considered to be provided for cosmetic reasons and functional prostheses are provided to enable the amputee to achieve his normal functions. Cosmetic prostheses are worn by people who have difficulties when operating active prostheses or are worn only for cosmetic reasons. Paper approaches the 3D scanning using Kinect and 3D reconstruction using Skanect software. The scanning and reconstruction were performed in the making of a cosmetic prosthesis of a finger. The study describes the phases from the scanning to the fabrication of the cosmetic prosthesis through 3D printing. The printer use melting or softening material to produce the layers of the object. The 3D printing of the cosmetic prosthesis should be made of a material that simulates human tissues with respect to texture, color, weight and translucency. This bioengineering application uses the Kinect based 3D scans. The involved techniques are modern and cost-effective. Compared with a manual manufacture, 3D printing of cosmetic prostheses has the advantages of shorter fabrication time and low cost.

Key words: cosmetic prosthesis, 3D scanning, 3D printing

1. Introduction

The most common causes of amputation in the world are vascular disease, industrial or environmental accidents, local wars, terrorist attacks and the lack of elementary public health which often leads to gangrene, and

*Corresponding author; e-mail: oct.ciobanu@gmail.com

infection. Multiple replacements of artificial limbs and repairs are necessary over a lifetime of an amputee. How well limbs perform and how cosmetically appealing they are depend on many variables including cost, the skills of the prosthetists and the materials that are available to fabricate the artificial limb. The design and the fit of prosthesis are what determine the patient's comfort and acceptance.

Prostheses were developed for function, cosmetic appearance and for psychological reasons. Passive or cosmetic prostheses are considered to be manufactured for cosmetic reasons and functional prostheses are manufactured to enable the amputee to achieve his normal functions. Cosmetic prostheses are worn only for cosmetic motives or are worn by people who have difficulties when operating active prostheses.

The present study describes the manufacturing phases of a cosmetic prosthesis of the right hand forefinger, from scanning to 3D printing. There are known a lot of applications of 3D printing in bioengineering area (Bassoli et al, 2012), (De Crescenzio et al, 2011), (Ciobanu, 2015)

2. Preprocessing Techniques

Manufacturing of a cosmetic prosthesis of a finger may be accomplished in two major steps: scanning and printing.

This paper approaches a low-cost scanning technique based on structured light. The Kinect depth sensor used in this work is based on a webcam-type peripheral and was launched in 2009. Due to the low cost, the Kinect is a very attractive device for use in bioengineering applications. Kinect projects infrared points onto 3D surface and the surface produces distorted points that are read by an infrared sensor. The infrared dots look as in Fig.1

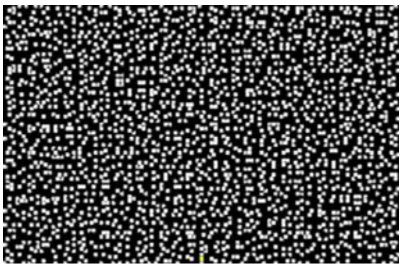


Fig. 1- Infrared dot patern projected by Kinect, visualized with a night vision camera

The array of projected dots changes size and position based on how far the details of objects are away. The color camera of the sensor also transmits data about the texture that are processed and used to reconstruct a 3D model of the scanned object. The infrared projector and the infrared camera create a depth map, which provides the distance information between an object and the camera as in Fig.2.

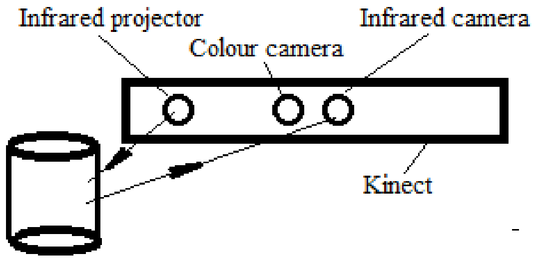


Fig. 2- Kinect interaction with an object

Kinect compares the observed size of a dot with the original size in the reference pattern. Any change in shape or size is transmitted to the depth calculations (Shin et al, 2013).

The distance from the object to the scanner is calculated by trigonometric triangulation. The angular field of view of the depth camera is 57° horizontally and 43° vertically. As the user and camera describe a trajectory in the space around the scene, data of the physical scene are revealed and fused. The system fuses depth data into a 3D model in real-time. A scanning system consists of depth sensor and 3D reconstruction software.

3. Experimental Results

The scanning was performed in day light, when lighting conditions were stable. The possible trajectories or positions of the Kinect sensor during scanning are presented in Fig.3a and b.

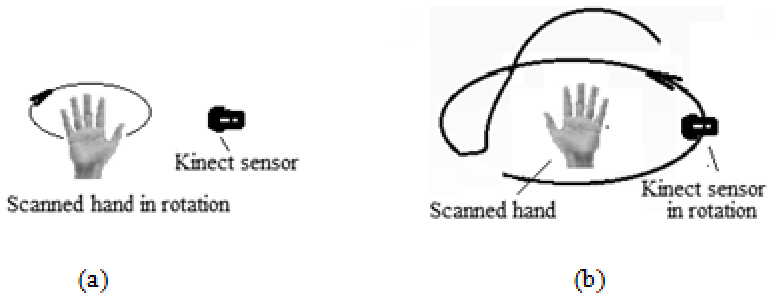


Fig. 3- Examples of Kinect sensor positions during scanning;
fixed camera (a) and mobile camera (b)

There are two options when scanning: rotating depth sensor around the hand or rotating the hand in front of depth sensor. Best results were obtained during rotating depth sensor around the hand at 400 or 500 mm distance.

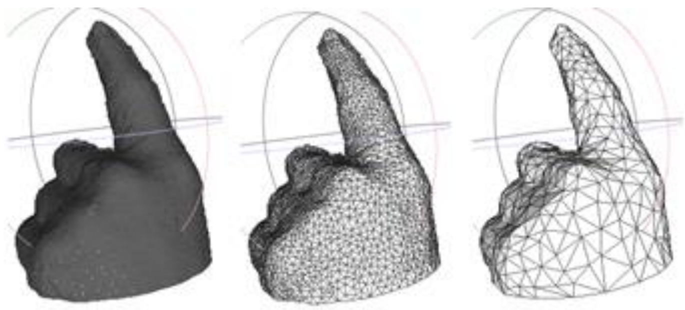
Fig 4 a shows the image of the left forefinger used in the scanning and fabrication of a cosmetic prosthesis for the deficient contralateral (right hand) forefinger.

(a) (b)

Fig. 4 - The scanned forefinger (a) and position of forefinger during scanning (b)

The position of hand and fingers during scanning is presented in Fig. 4b. The image was extracted from a control window of the Skanect software. The Kinect sensor performed a rotation around the hand.

The resultant 3D models of a forefinger after scanning with Kinect and after 3D reconstruction with Skanect software are presented in (Fig.5).



(a) (b) (c)

Fig. 5- The 3D model of the left forefinger with 200,000 faces (a), 10,000 faces (b) and 1,000 faces (c) after scanning and reconstruction

The 3D model produced by Skanect software may contain different irregularities and need a short phase of finishing. Fig. 6 shows the 3D model finished in Rhinocersos, a Computer Aided Design software for 3D modeling.

Skanect has 3 processing steps for 3D reconstruction: Record, Reconstruct and Process. There is also a separate window, Share, used for exporting of 3D models in PLY, OBJ and STL formats.

Fig. 6 - The final 3D model of the forefinger finished in Rhinoceros software

Printing phase

The last step was the printing of the cosmetic prosthesis. There are a lot of printing offices offering affordable and convenient printing and production services for students, industry and the public. The printing was made at a specialized printing office and performed with an Ultimaker 2 machine (see Fig. 7 a). The printer used polylactic acid (PLA), thermoplastic aliphatic polyester.

(a) (b)

Fig. 7 -The 3D printer used in forefinger fabrication (a)
and the final product (b)

Finally, the cosmetic prosthesis (Fig. 7 b) will receive a coat of color, using oil colors with a wax medium.

The success of this coating will depend entirely upon the artistic skill of a technician. In complex cases it will be necessary the help of a specialist in anaplastology in order to restore an absent part of the human body through artificial means.

5. Conclusions

1. The study showed that 3D scanning and printing of a cosmetic prosthesis using Kinect and a 3D printer is feasible and has the advantages of shorter fabrication time and low cost. Kinect sensors and 3D printers are cheap and they will become as popular and common as the personal computer; this means that almost every prosthetist can afford to have Kinect depth sensors and desktop 3D printers to print any simple prosthesis or orthosis.

2. Besides hardware, a cosmetic prosthesis modern fabrication needs reconstruction software (Skanect) which is cheap and easy to use.

3. A printed finger looks much like a real human finger in shape but it requires much further process and refinement for detail.

Acknowledgements. The authors gratefully acknowledge the funding from the European Commission – Lifelong Learning Programme / Leonardo da Vinci, project No. 540170-LLP-1-2013-1-TR-LEONARDOLM. This publication reflects the views only of the authors, and the Commission and the National Agency cannot be hold responsible for any use which may be made of the information contained therein.

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FABRICAREA PROTEZELOR COSMETICE PRIN UTILIZAREA SCANĂRII 3D ŞI A IMPRIMĂRII 3D

(Rezumat)

Lucrarea de faţă abordează fabricarea unei proteze cosmetice de deget prin utilizarea scanării 3D cu ajutorul senzorului Kinect şi prin imprimarea 3D. Lucrarea descrie fazele de lucru de la scanare la imprimarea 3D. Sunt descrise diverse prelucrări de grafică ale modelului 3D obţinut după scanarea cu senzorul Kinect. În soluţia de fabricare descrisă, senzorul Kinect, programele de prelucrare a imaginilor şi materialele sunt moderne şi la preţuri convenabile.