Three-dimensional (3D) scanning using Microsoft® Kinect® Xbox 360® scanner for fabrication of 3D printed radiotherapy head phantom

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Abstract. Radiotherapy phantoms are essential equipment for treatment verification and quality assurance. Recently, development in 3D printing technology provides an opportunity for fabricating patient-specific radiotherapy phantom that has many potential applications in clinical and research. This study investigates the application of Microsoft Kinect® Xbox 360 scanner to model human topography for 3D printed radiotherapy phantom fabrication. The feasibility and performance of the Kinect® scanner were tested on a standard commercial head phantom. The scanned head image was then edited and adapted for 3D printing. The finding suggests that the radiotherapy phantom can potentially be developed using the Kinect® sensor, which is easier and cheaper to operate in comparison to other techniques of fabricating 3D printed radiotherapy phantom.

1. Introduction

The human body is a complex task as the radiation dose cannot be directly measured, thus needs to be replaced by tissue-equivalent materials known as phantom [1]. Phantoms are made from tissue-equivalent materials that represent the natural part of human anatomy and attenuation characteristics for radiation dosimetry. In radiotherapy, standard commercial phantoms such as anthropomorphic phantom are used to represent patients for quality assurance and verification of treatment techniques. This commercial phantom is expensive, and most of the time, did not represent the actual patient condition.

The development of 3D printing technologies in recent years has also found its application in radiotherapy phantom development. Several studies have demonstrated the application of 3D printing as a tool to produce radiotherapy phantom [2]. Studies by Craft et al. (2017) present the preparation and fabrication of patient-specific radiotherapy phantom using 3D printing from patient CT scan data [3]. Another study by Park et al. (2017) developed a 3D printed bolus using a 3D scanner [4]. Meanwhile, Dipasquale et al. (2018) used a surface scanner to produce radiotherapy bolus [5]. In contrast to using patient CT data to obtain patient-specific topography, the use of low cost, structured light, 3D optical scanner are more comfortable and reduce unwanted radiation dose to patients [6]. In this research, we examine the feasibility of a Microsoft Kinect® Xbox 360® sensor to scan and modeled the radiotherapy head phantom for 3D printing.

2. Materials and Methods
The Microsoft® Kinect® sensor is a low cost, high resolution, and short-range 3D scanning camera developed for the Microsoft® Xbox 360® video game system. The Kinect®, as shown in figure 1a, has a variety of advantages such as it can measure depth and color at video rate simultaneously in comparison to another type of 3D scanner [7]. Central to the entire discipline of Kinect scanner is the concept that based on webcam-style add-on peripheral. Kinect contains three vital pieces that work together to detect users motion and create users' physical image on the screen: an RGB (red, green, blue) colour with a depth sensor (D), VGA (video graphics array) camera, and a multi-array microphone [8]. These specifications of the Kinect provide a vital criterion as a great scanner to obtain the topography of the phantom.

In this study, we evaluate the Kinect® sensor by performing 3D scanning involving the head of the Alderson RANDO® phantom (The Phantom Laboratory, Salem, NY, USA), as shown in figure 1b. The scanning positioning set up of the scanner and RANDO® phantom is illustrated as in figure 2. The scanning distance between the phantom and scanner is ± 50 cm, and the scanner angle is ± 10°. The scanning was performed 360° around the phantom and needed to be repeated several times to ensure an adequate amount of data obtained by the scanner [6]. Figure 3 shows the scanning process at 0°, 45°, 270°, and 360° position. The Kinect® was connected to a desktop with scanning application software of Skanect (Occipital, Inc. Boulder, Colorado, USA) to acquire and render the phantom image. The obtained images were then also edited using 3D Builder (Microsoft® Corporation, Albuquerque, Mexico). Image data is saved in stereolithographic (STL) format that is a compatible file type for 3D printing.

![Figure 1](image1.png)

**Figure 1.** a) Microsoft® Kinect® sensor b) Head of the Alderson RANDO® phantom

![Figure 2](image2.png)

**Figure 2.** Schematic diagram of the set up between the Kinect® scanner and the Rando® phantom
3. Results and Discussion

The total scanning time to obtain the image is estimated at around 1 to 2 hours ascribable to the low video-rate procured; ±10 frames per second (FPS). Hence, the scanning process is repeated several times to gain the optimum image data. It is vital to ensure both phantom and scanner to be static during image acquisition to avoid data tracking lost. The scanned image will be edited, and surface rendered to ensure a smooth external surface [6]. The limitation exists when the scanner tends to consume more time as the scanning process delayed continuously due to the slow processor of the computer. For future augmentation, a computer with higher central processing unit (CPU) is needed to capture a streamlined video with high-speed FPS. The computer that was used should have a more significant memory (RAM) to contain and run the applications smoothly.

The previous study on developing 3D-printed patient-specific phantom is usually by abstracting patient data from CT images, digitized radiographs, or scanning using optical scanner [3, 9-11]. Meanwhile, in this study, the method implemented 3D scanning using a Kinect® Xbox 360® scanner to obtain the surface topography of the phantom that might later be applied to acquire patient surface anatomical structure. The final image in the STL format is shown in Figure 4 and ready to be 3D printed. Phantom interior designs are provided with two options, whole with slots and hollow slot insertion, as shown in Figures 4a and 4b.

Figure 3. The repeated 360° clockwise scanning process using Skanect software; a) 0° position, b) 45° position, c) 270° position and d) 360° position.

Figure 4. Options for 3D printing a) Whole phantom b) Hollow phantom
4. Conclusions
This study has shown the feasibility of the Microsoft Kinect® Xbox 360® scanner to create a high resolution and accurate image for the production of the 3D printed patient-specific radiotherapy phantom. The application of 3D printed patient-specific radiotherapy phantom for quality assurance and treatment verification might improve the overall treatment quality in radiotherapy, especially using a low-cost type of scanner to obtain patient image data.

5. References
[1] Rahman M A, Bhuiyan M T H, Rahman M M and Chowdhury M N 2014 Mal. J. Med. Biol. Res. 3 19-24
[2] Izzo R L, O’Hara R P, Iyer V, Hansen R, Meess K M, Nagesh S V S, Rudin S, Siddiqui A H, Springer M and Ionita C N 2016 Proc. SPIE. Int. Soc. Opt. Eng. 9789 1-16
[3] Craft D F and Howell R M 2017 J. Appl. Clin. Med. Phys. 18 1-8
[4] Park J W, Oh S A, Yea J W and Kang M K 2017 J. PloS One. 12 1-9
[5] Dipasquale G, Poirier A, Sprunger Y, Uiterwijk J W E and Miralbell R 2018 J. Rad. Oncol. 13 1-8
[6] Sharma A, Sasaki D, Rickey D W, Leylek A, Harris C, Johnson K, Aviles J E A, McCurdy B, Egtberts A and Koul R 2018 J. Adv. Rad. Oncol. 3 288-96
[7] Cui Y and Stricker D 2011 Proc. 2nd Int. Conf. 3D Body Scanning Technologies 121-8
[8] Cruz L, Lucio D and Velho L 2012 Kinect and rgbd images: Challenges and applications. In 25th SIBGRAPI Conf. on Graphics, Patterns and Images Tutorials. (New Jersey: Piscataway) pp 36-49
[9] Clarkson S, Wheat J, Heller B and Choppin S 2016 J. Sports Sci. 34 1006-14
[10] Abdullah K A, McEntee M F, Reed W and Kench P L 2018 J. Med. Rad. Sci. 65 175-83
[11] Caldwell C B and M J Yaffe 1990 J. Med. Phys. 17 273-80

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