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Abstract. Proper positioning of the patient in the CT examination is important. Patients who are not properly positioned at iso-center can affect the distribution of radiation dose. Every patient is unique, hence matching a center of the patient with the iso-center is not a trivial task. This study has developed a system for automatic patient centering using a Kinect camera located at the right or left side of a patient. A plastic water slab phantom was used for calibrating pixel value and pixel size for various distances. Twenty patients were automatically positioned by the Kinect camera and the results were compared to manually positioning by medical personnel. It was found that the value and size of the pixel depend on the Kinect camera-object distance. The value and size of pixels linearly increase with the increase of distance. The difference between the manual patient positioning by medical personnel and the automatic method by the Kinect camera was 1.80 ± 0.95 cm. The difference for the 6 patients was more than 2 cm, and for the 14 patients was less than 2 cm. Hence, the Kinect camera with automatic software can help in positioning patients automatically and accurately in real-time so that it can reduce time and effort in finding patient centers.

Keywords: Patient centering, depth image, patient positioning.

1. Introduction

Computed tomography (CT) scans use X-ray ionizing radiation and expose patients from various directions to obtain tomographic images, thereby delivering a relatively high dose to patients [1,2]. The use of CT must be optimized by the ALARA principle so that the dose received by the patient is as low as possible consistent with a resulting image that is of sufficient quality to make the diagnosis [3]. One way to optimize dose in CT is to use a filter. The filter used by a CT scan is called a bowtie filter and is thicker at both ends than in the middle part. It is intended to homogenize the dose received by the patient if patients are properly positioned at the iso-center [4]. However, if the patient on the CT table is higher or lower than the iso-center, it causes some of the body to receive more radiation than other parts [5].

Each patient is unique and has a different size, so it is not possible to determine the patient center permanently. It means that the center of each patient may be above or below the iso-center [6]. Up until now, the iso-center has been indicated by lasers and the determination of the center of the patient

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has been manually carried out by medical personnel. This approach depends on the experience and expertise of the personnel and it may lead to inaccuracies because of its subjective nature [7]. Therefore, a system for determining the centering of the patient's position objectively and automatically is needed.

In a previous study, the detection of body contours to determine the position of patients in CT was carried out using a 3D camera [8,9]. This resulted in a median difference between the results of automatic patient positioning and a manual of 6.1 mm [8]. However, the 3D camera system in that study was permanently installed on a fixed position in the upper gantry of CT scans, so the camera could not be used for other CT scans in a hospital installation. In this study, we will develop a centering determination system for CT examinations using a portable Kinect camera (Microsoft Game Studio), that can be positioned on either side of the patient and which can be moved to other CT machines. The Kinect camera is a line of motion sensing input device for computer game consoles, which employs infrared (IR) transmitters and IR sensors to capture data and compose a 3D depth image [9].

2. Methods

2.1. Research procedure

This study was conducted in Diponegoro National Hospital (RSND), Semarang, from February to April 2019. Determination of the center of the patient employed a Kinect camera. The Kinect camera was connected to a laptop with a software for automatic segmentation and centroid determination. The resulting images were then calibrated using a 30 cm plastic water slab phantom with a thickness of 4 cm. The system was implemented with 20 patients who underwent CT examination of the head, and the Kinect camera was used to determine the center of the phantom and the patient's head.

2.2. *Set-up of Kinect camera*

The Kinect camera (Kinect for XBOX 360) was located on either the right or left side of the patient as shown in Figure 1. First, the phantom center was fixed at the iso-center of the gantry bore guided by a laser, the Kinect camera was then placed in front of the phantom at a specific distance, and was activated to capture the image of the phantom. The software automatically segmented the phantom and then determined the center of the image and center of the phantom.

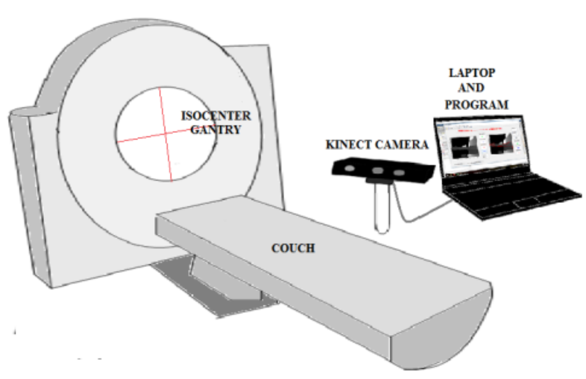

Figure 1. Position of the Kinect camera to automatically determine the center of a patient.

If the center of the phantom image (determined by the Kinect camera) coincided with the "true" center of the phantom (determined by laser), then the Kinect camera was properly positioned. However, if the center ofphantom determined by the Kinect camera did not coincide with the "true" center of the phantom, the camera should be moved until the center of phantom coincides with the true center. If the Kinect camera was properly positioned, then it can be used to determine the center of the patient after calibration.

2.3. Calibration of Kinect camera

The image from the Kinect camera is called a 3D image. The image is composed of pixels representing a distance from the object being captured [10]. Therefore, every pixel value should be calibrated with a known distance to the object. It also is noted that the area of every pixel depends on distance. Hence, the area of every pixel should also be calibrated.

The calibration of the Kinect camera used a water slab phantom with a thickness of 4 cm and an area of 30 x 30 cm^2. The phantom was positioned in front of the Kinect camera at various distances. For every distance, the pixel value and pixel size were determined.

The pixel value was calculated by the average pixel values within the region of interest (ROI). The size of the pixel was determined by using two electronic calipers as shown in Figure 2. By comparing the result of the electronic caliper and the size of the water slab (30 cm), the size of every pixel could be determined.

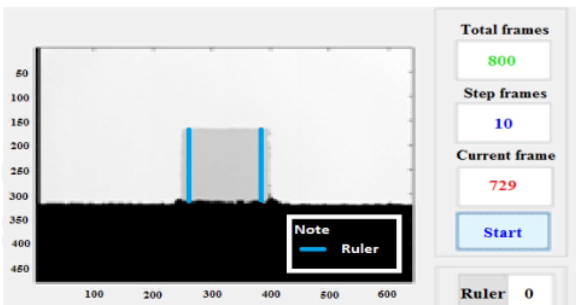

Figure 2. Measuring both sides of the phantom using a ruler for calibration of pixel size.

2.4. Determining the position of the patient center

When the patient is positioned manually by medical personnel, the Kinect camera recorded and took the patient's depth image and then detected the patient's body area by automatic contouring. Based on the result of auto-contouring, the body's centering was measured using the centroid equation

$$Centroid = \frac{\Sigma y_i}{n_y} \quad (1)$$

With $y_i$as pixel position within segmented phantom and $n_y$number of pixels within the phantom.An example of the result of the automated determination of the center of a patient is shown in Figure 3. The green dot represents the center of the image (i.e. iso-center) and the blue dot represents the center of the patient. The difference in y-coordinates between the image center and the patient center was then determined.

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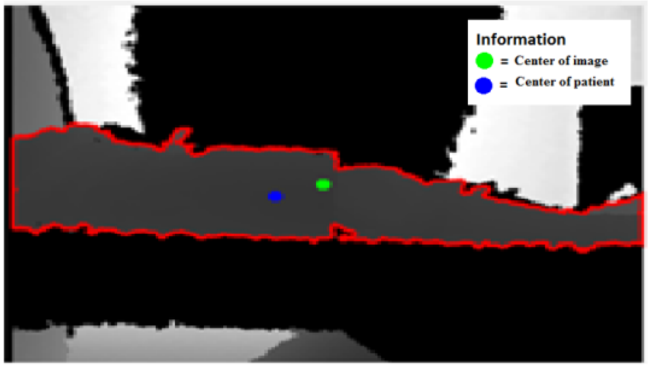

Figure 3. Example of the automated determination of patient center. The green dot represented the center of the image (i.e. iso-center) and blue dot represented the center of the patient.

3. Results

3.1. Calibration of the Kinect camera

The image that is captured by the Kinect camera is a depth image representing the distance from the object being imaged. Figure 4 shows the relationship between the Kinect-object distance and the pixel value of the image. It can be seen that the Kinect-object distance and the pixel value of the image are linearly dependent, as described by equation $y = 0.99x + 1.53$ with $R^2 = 0.99$.

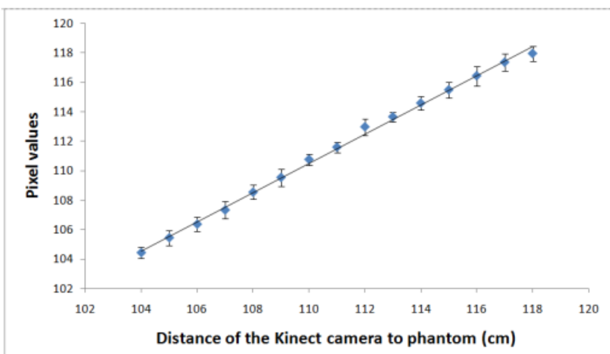

Figure 4. The relationship between the Kinect camera-object distance and the pixel values of the image.

The relationship between the Kinect camera-object distance and the number of pixels of the image object (slab phantom) on the left side and the right side of the phantom is shown in Figure 5. The pixel number of slab phantom decreases with the increasing distance according to $y = -1.59x+334.2$with $R^2= 0.90$.

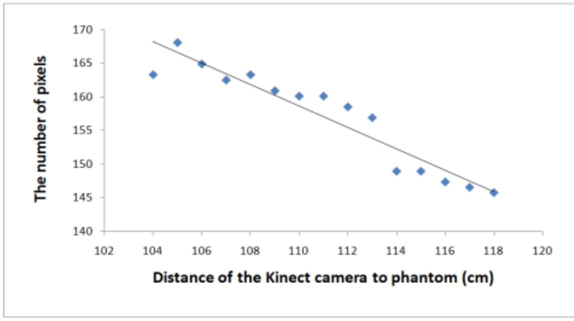

Figure 5. The relationship between the distance of the Kinect camera to the phantom and the number of pixels.

From the relationship between the Kinect camera-object distance and the pixelsize (Figure 6), the size of pixel increases linearly with the increase of distance and corresponds to equation y = 0.02x+0.27with R^2=0.89.

3.2. Determining the position of the patient center

A total of 20 patients underwent a CT examination of the head, and the center of the patient was determined manually by medical personnel and automatically by the Kinect camera. The results of patient positioning can be shown in Table 1. It shows that there are little differences between both systems. The difference range is between 0.05 and 3.51 cm with an average of 1.80 ± 0.95 cm.

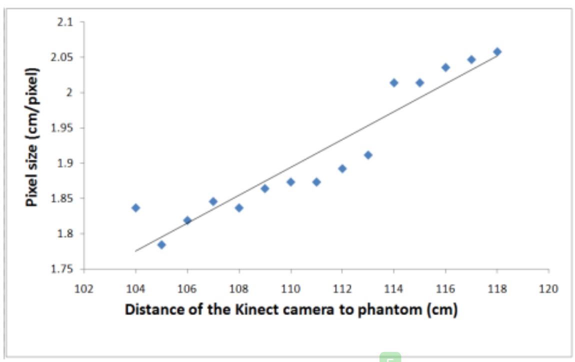

Figure 6. The relationship between the distance of the Kinect camera to the phantom and the pixel size.

Table 1. Patient table height determined manually and automatically using a Kinect camera, and the respective differences (mis-centering).

Manual table height (cm)	Table height determined by Kinect camera (cm)	Difference value (cm)
16.70	18.38	1.68
17.10	18.00	0.89
20.50	21.60	1.10
16.00	16.05	0.05

18.10	20.30	2.20
20.20	20.78	0.58
18.70	20.17	1.47
17.30	19.08	1.78
21.20	24.55	3.35
14.20	15.14	0.94
16.20	17.67	1.47
17.20	19.03	1.83
15.10	16.51	1.41
14.20	16.66	2.46
18.40	21.33	2.93
16.90	18.47	1.57
16.00	17.62	1.62
21.70	25.21	3.51
18.10	21.61	3.51
16.00	17.52	1.52
Average		1.80
Standard deviation		0.95

4. Discussion

This study successfully developed a system for automatic patient positioning in CT examinations, usinga Kinect camera located on the left or right side of the patient. We confirmed that the 3D camera of Kinect produces an image in which the pixel value linearly correlates to the distance of the object being captured. The minimum difference value of the automatic patient positioning compared to manually positioning by medical personnel was 1.8 ± 0.9 cm.

Previously, Booij et al. [8] reported on the accuracy of 3D cameras located in the upper CT gantry for the detection of body contour and patient position in CT. Their results showed the median value for the difference between table height and the manual position was 1.32 cm [8]. Their result is slightly better than in this study because the 3D camera system used was fully integrated into the scanning system workflow. In our current study, the Kinect camera was placed on the right side of the patient, so the potential to move is higher. However, our system has the advantage that it is can be easily moved to other CT systems.

Moreover, if the Kinect camera holder is stable, the possibility of the accuracy of this automation system can be increased. Our results show that the automatic determination of the position of the patients in this study resulted in all patient positions being under the iso-center. A previous study on the impact of mis-centering on eye doses using the head CTDI phantom revealed that a mis-centering of 2 cm below the iso-center increases the eye dose by about 20% [4,6]. Therefore, from these results, adifference of 1.80 ± 0.95 cm corresponds to ± 20% dose difference for an organ located in the upper body such as the eye lens.

There are limitations to this study. First, only 20 patients were used. In a follow-up study, we will evaluate the system using more patients with different CT examinations. Second, this study compared the automated patient positioning with manual positioning by medical personnel. The determination of patient centering by medical personnel is subjective. It is not a reference value since the correct reference would be from axial CT images. Our follow-up study will compare the results of automatic centering with the centering measured from axial CT images.

5. Conclusion

Patient positioning can be automatically carried out using a Kinect camera with its position next to the patient. It was found that the differences in the results of positioning patients with the Kinect camera and manual determination was 1.80 ± 0.95 cm.

References

[1]. Kim S, Song H, Samei E, Yin F, Yoshizumi T T 2011 Computed tomography dose index and dose length product for cone-beam CT: Monte Carlo simulations of a commercial system *J. Appl. Clin. Med. Phys.***12** 84-95

[2]. Anam C, Fujibuchi T, Haryanto F, Widita R, Arif I and Dougherty G 2019 An evaluation of computed tomography dose index measurements using a pencil ionisation chamber and small detectors *J. Radiol. Prot.***39** 112–124

[3]. Anam C, Budi WS, Adi K, Sutanto H, Haryanto F, Ali MH, Fujibuchi T and Dougherty G 2019 Assessment of patient dose and noise level of clinical CT images: automated measurements *J. Radiol. Prot.* **39** 783–793.

[4]. Habibzadeh MA, Ay MR, Kamali Asl AR, Ghadiri H and Zaidi H 2012 Impact of miscentering on patient dose and image noise in x-ray CT imaging: Phantom and clinical studies *Phys. Med.***28** 191-199

[5]. Toth T and Ge Z 2007 The influence of patient centering on CT dose and image noise *Med. Phys.* **34** 3093-3101

[6]. Anam C, Fujibuchi T, Toyoda T, Sato N, Haryanto F, Widita R, Arif I and Dougherty G 2019 The impact of head miscentering on the eye lens dose in CT scanning: Phantoms study *J. Phys. Conf Series.***1204**012022

[7]. Li J, Udayasankar UK, Toth TL, Seamans J, Small WC and Kalra MK 2007 Automatic patient centering for MDCT: Effect on radiation dose *Am. J. Roentgenol.***188**547–552.

[8]. Booij R, Budde RPJ, Dijkshoorn ML and Van Sraten M 2019 Accuracy of automated patient positioning in CT using 3D camera for body contour detection *Eur. Radiol.* **29**2079-2088

[9]. Saltybaeva N, Schmidt B, Wimmer A, Flohr T and Alkadhi H 2018 Precise and automatic patient positioning in computed tomography: Avatar modeling of the patient surface using a 3-dimensional camera *Invest. Radiol.* **53**641-646

[10]. Stefanie T L,Elaine FH,Christopher JT and Susan MA 2016 Evaluation of kinect 3D sensor for health care imaging *J. Med. Biol. Eng.* **36** 857−870.

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