

# Construction of a patient observation system using KINECT™

**Kazunori Miyaura**<sup>1,3</sup>, **Yu Kumazaki**<sup>1</sup>, **Chika Fukushima**<sup>2</sup>, **Shingo Kato**<sup>1</sup>, **Hidetoshi Saitoh**<sup>3</sup>

<sup>1</sup> Saitama Medical University International Medical Center, Hidaka-shi Saitama 3501298 Japan

<sup>2</sup> Technology of Radiotherapy Corporation, Bunkyo-ku Tokyo 1120002 Japan

<sup>3</sup> Tokyo Metropolitan University Graduate School of Health Sciences, Arakawa-ku Tokyo 1160012 Japan

E-mail: kmiyaura@saitama-med.ac.jp

**Abstract.** Improvement in the positional accuracy of irradiation is expected by capturing patient motion (intra-fractional error) during irradiation. The present study reports the construction of a patient observation system using Microsoft® KINECT™. By tracking movement, we made it possible to add a depth component to the acquired position coordinates and to display three-axis (X, Y, and Z) movement. Moreover, the developed system can be displayed in a graph which is constructed from the coordinate position at each time interval. Using the developed system, an observer can easily visualize patient movement. When the body phantom was moved a known distance in the X, Y, and Z directions, good coincidence was shown with each axis. We built a patient observation system which captures a patient's motion using KINECT™.

## 1. Introduction

Reduction of the planning target volume (PTV) margin and the setup of exact internal target volume (ITV) are important in advanced radiotherapy [1]. Intra-fraction motion can be caused by the respiratory, musculoskeletal, cardiac, and gastrointestinal systems [2]. Improvement in irradiation position accuracy is expected by capturing the motion (intra-fractional error) during patient irradiation. A common patient observation system is expensive and more complicated program. The purpose of this study is to construct a patient observation system using Microsoft® KINECT™.

## 2. Method

KINECT™ is a tool that uses speech recognition, a motion sensor, frame pursuit, etc. [3]. A frame pursuit has the skeletal tracking method. This method can locate the joints of the tracked targets in space and track their movements over time. We constructed our KINECT™ system in two stages.

Figure 1 shows the sensor array of the KINECT™ system. This size is 65 × 280 × 70 mm (length × width × height). It has a color camera and two sensors. The system runs on the Microsoft® Windows® Software Development Kit (SDK). KINECT™ has the following features [3].

- An RGB camera that stores 3-channel data at 1280×960 resolution.
- An IR emitter and an IR depth sensor.
- A multi-array microphone, which contains 4 microphones for capturing sound.
- Skeletal Tracking allows KINECT™ to recognize people and follow their actions.

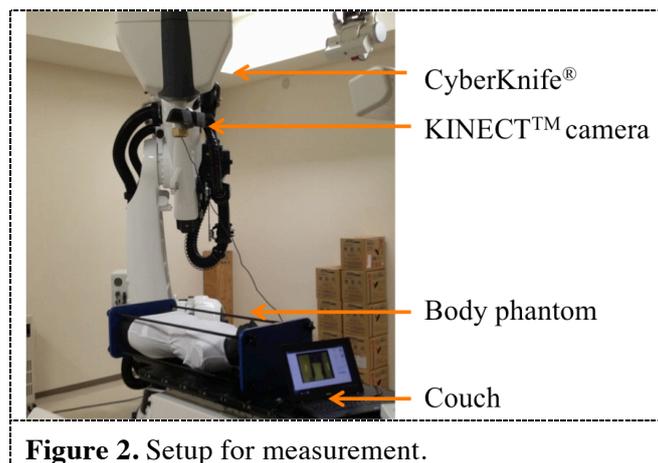
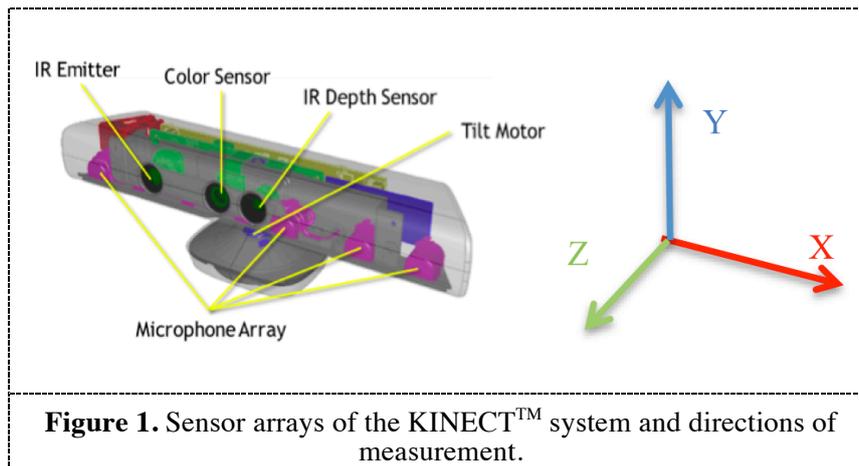


### 2.1. Development of the Interface

First we developed an interface to display body motion using Microsoft® Visual Studio 2010 and Visual C#. The input to the system is a 640 × 480 15 Hz YUV color image of the body phantom and a corresponding depth image provided by KINECT™.

### 2.2. Accuracy of the measurement

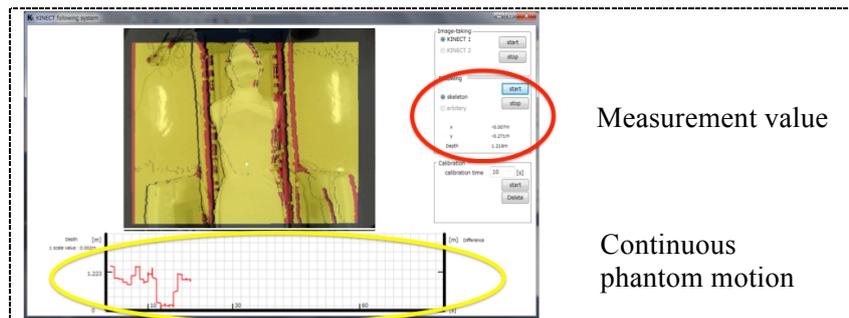
Second, we verified the accuracy of the measured value of the physical shift received by the KINECT™ mounted on the CyberKnife® gantry head. The body phantom on the couch was displaced in the X, Y, and Z directions, and the displacement was measured by KINECT™ using a skeletal tracking method. The method does not need a marker. The phantom was moved in 1-cm steps from -5 cm to 5 cm for all directions. Distance from KINECT™ to the target was based on 100 cm.



This system runs on a computer equipped with an Intel® i5 quad-core 3550 CPU with 4 GB of RAM.

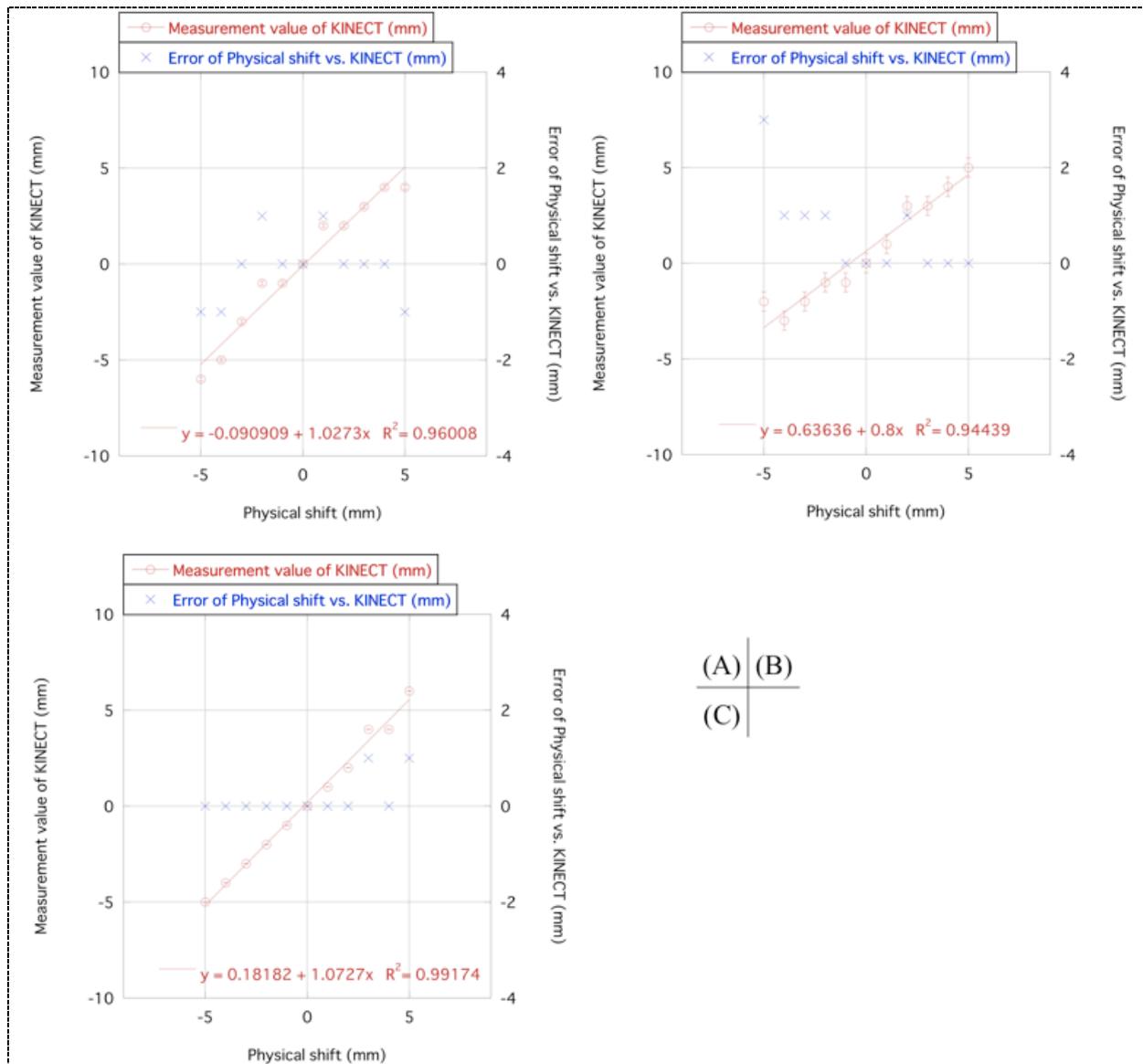
### 3. Results/Discussions

Figure 3 shows indicative results displayed on the interface. We developed the interface to display 3 directions of motion (X, Y, and Z) continuously as a graph.



**Figure 3.** Indicative results displayed on the interface.

Measurements were performed 10 times for each point, and the average value is shown in the graphs. An error bar shows the standard deviation of each measurement.



**Figure 4.** Quantitative evaluation of the performance of this system with respect to (A):X = Lateral (B):Y = Longitudinal (C):Z = Vertical

Figure 4 shows a quantitative evaluation of the performance of this system with respect to 3 directions. The upper left graph (A) shows the result in the  $X$  (lateral) direction, the upper right graph (B) showed the result of  $Y$  (longitudinal) direction, and, lower graph (C) shows the results of  $Z$  (vertical) direction. The horizontal axis displays the physical shift by the couch in the graph. The vertical axis displays the measurement value of KINECT™ and the error of physical shift vs. the measurement by KINECT™.

In the present study, the correlation coefficient was high in all directions. Errors of physical shift vs. KINECT™ were less than 1 mm in all directions. Standard deviations in the  $Y$ -direction at each point were larger than those in the  $X$  and  $Z$  directions because the effective field of view in the  $Y$  direction was narrower than that in the  $X$  direction.

Accuracy of position recognition in the  $Z$  direction was higher than in other directions, because this direction was measured with the IR camera. Further, its spatial resolution is higher than that of the color camera. It was considered that the detection sensitivity in the  $Z$  direction was higher than that in the other directions. The skeletal tracking method might depend on the direction of motion detection. In future work, we need to perform accuracy verification as shown in the report of AAPM Task Group 147 [4].

#### 4. Conclusion

In the present study, we constructed a patient observation system using the Microsoft® KINECT™ system. Our system is simple and inexpensive and made it possible to track body motion.

#### 5. References

- [1] John L. Meyer 2011 IMRT, IGRT, SBRT-Advances in the Treatment Planning and Delivery of Radiationtherapy.
- [2] Keall PJ, Mageras GS, Balter JM, et al. 2006 The management of respiratory motion in radiation oncology report of AAPM Task Group 76. *Med. Phys.* **33** 3874.
- [3] <http://www.microsoft.com/en-us/kinectforwindows/>
- [4] Willoughby T, Lehmann J, Bencomo JA, et al. 2012 Quality assurance for nonradiographic radiotherapy localization and positioning systems: Report of AAPM Task Group 147. *Med. Phys.* **39** 1728

#### Acknowledgments

We appreciate R-Tech, Inc., for their cooperation in this study.