Development of a low-cost and clinically available patient intrafraction motion monitoring system

Statement of Innovation / Impact: We have developed a flexible system in order to monitor the intrafraction motion [1,2]. The system accuracy has been satisfied with the tolerance values of AAPM Task group 142 report [3]. The purpose of our study is the following:

1) In order to avoid interferences of patient’s body and linac gantry, a standard webcam is extended with a low cost telescope enables the effective distance for webcam image acquisition.

2) Our new algorithm in the system could account for patient’s rotation to measure the intrafraction motion more accurately. The ideal situation for our system would be that the marker movement is toward the axis perpendicular to the axis of the camera. However, patient can move in all directions during treatment even with immobilization system. The patient’s movement with rotation would affect to decrease the accuracy of the measurement of the intrafraction motion.

Method and Materials: Figure 1 shows our experimental setup. Our system is composed of a standard web camera with a low-cost and 8x magnitude telescope, a personal computer with our in-house software and a specific marker box. All of the components could be installed with low cost.

The dynamic calibration algorithm was developed to take into account for patient’s rotation during treatment in order to measure the intrafraction motion more accurately (Fig.2). The direction of the vector of the main marker’s movement and the two calibration markers’ movement would be changed depending on patient’s rotation simultaneously. Using the relationship, the distance per pixel is calibrated while measuring the intrafraction motion. In order to track the main marker and the two calibration markers simultaneously, we implemented parallel CPU computing. To identify the locations of individual markers on motion image, the sum of squared differences technique was implemented as template matching technique and also gray-scale image frames are utilized for faster computation of the template matching.

To evaluate the system, a Quasar respiratory motion QA phantom was used with 10 mm-amplitude and 3.0 sec-period. Distance between the camera and the marker box was set at 100cm. Using our system, the amplitudes were measured under the different angles of the web camera setting (0 to 50 degree, 5 degree step). The measured values were compared with the values measured by Varian Real-Time Position Management (Varian-RPM) System.

Results and Discussion: The result of the amplitudes measured by our system and Varian RPM-System are 10.2±0.3 mm and 10.3±0.1mm at the angle of 0 deg., respectively. The values of both systems were within the tolerance value of AAPM Task group 142. The results of the amplitude of our system and Varian-RPM system were 10.2±0.3mm and 10.4±0.1mm, respectively, while the angle was changed. With the parallel CPU computing, the calculation time to measure the position of the marker was about 50msec including the latency.

Conclusions: Our intrafraction monitoring system could have clinically acceptable accuracy of position measurement with sufficient temporal resolution even if clinically possible and complicated situations were arisen, such as patient’s rotation. In addition to it, our system would be contributed broadly to improve the treatment accuracy so that the system could be implemented at low cost.

References: