Isocenter and Field of View Accuracy Measurement Software for Linear Accelerator

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Abstract. For radiotherapy, Linear Accelerator (Linac) quality assurance is necessary to provide precise and accurate radiation treatment. Besides treatment plans and patient positioning, machine status is another vital issue that affects radiotherapy. In this paper, we implemented and discussed the Isocenter and Field of View Accuracy Measurement Software for Linac. All data and images were taken by Brainlab Vero Linac of Erlangen University Clinic.

Keywords: Image processing, linear accelerator, quality assurance program, star-shot analyzing algorithm

1 Introduction

In general, quality assurance means all planned or systematic actions for guaranteing the given requirements. In radiotherapy, quality assurance refers to all procedures that ensure consistency of medical prescriptions and practical fulfillment [1].

According to radiation therapy workflow, treatment planning system TPS plans, the treatment details based on assumption of real Linac parameters; also, during irradiation, patient positions are compared to radiation isocenter for patient positioning. For accuracy considerations, consistency of treatment planning assumption, patient positioning, and actual machine status are critical, which also means that regular assurance of machine quality is necessary.

Besides dosimetric accuracy, the machine quality assurance can also increase the probability of recognition and rectification accidents or fault in case when they do occur. Minor incidents can occur anytime, as well as by prompt recognition, we can modify sequential fractions and, thus, reduce overall consequences.

The objective of machine QA is to ensure exposure of normal tissue during irradiation be kept ALARA (as low as reasonably achieved), so as to integrate patient safety by reducing machine uncertainty.

Usually, quality assurance includes a certain types of measurements: isocenter accuracy, field of view (FOV) accuracy, multileaf collimator MLC leakage, dynamic MLC banks position, leaf position, one picket test, and MLC leakage ratio. The first two types of measurements are the most important for delivering a certain radiation dose to the object.

2 Method and Material

2.1 Film

In this article, we use EDR2 (Extended Dose Range) film for evaluation of dose exposure. The EDR2 film developes in case exposed in normal environment, thus, during measurement, the film should be covered by opaque paper, and in this article, we make use of such property for field reference. Before irradiation, we puncture reference point (light field vertex or longitudinal direction) with needle on cover, so as to develop a small dot for reference for the analysis.

The EDR2 film needs developing procedure before analysis, and we have developed the film by automatic developing device, but considering average cost, it is quite worth to substitute it by instant self-developing for the EDR2 film.

2.2 Electronic Portal Imaging Device (EPID)

EPID is used for several processes. For example, patient positioning, verification and dosimetric verification of IMRT, and Linac quality assurance. Quality assurance is based on EPID and offers high spatial resolution, fast image acquisition, and digital output. It is considered as an accurate tool for both patient and machine QA in radiation therapy [2].

2.3 Isocenter Accuracy Measurement

In this article, we measure the accuracy of beam isocenter with rotation of gantry and rings. We set the MLC window width to be identical 10 mm and irradiate from different direction and compare the area of isocenter sphere with expected value [3].

Isocenter sphere for gantry-rotation. We clamp the film between two plastic blocks to fix and place it corresponding to the expected beam isocenter by laser (Fig. 1). Then we irradiate with the MLC window size of $10 \times 50\ mm^2$ and from gantry angle of 0, 70, 140, 210, 280, and 350 degree. After that, film is scanned and analyzed.

Isocenter sphere for ring-rotation. Similarly to the gantry-rotation test, we make the film positioning direction towards the beam portal. We change the MLC window size to $10 \times 150\ mm^2$ and irradiate from different ring angles. Film is also scanned for the analysis step.

2.4 FOV Accuracy Measurement

In this test, we measure correlation of the light-field, as well as the irradiation field and we choose $50 \times 50\ mm^2$ and $100 \times 100\ mm^2$ field for test. First, we place the film towards beam portal and puncture four corners corresponding to the light-field on film, then we change the MLC window size to the same and irradiate with dose of 300MU. The film is later analyzed by scanner after being developed.

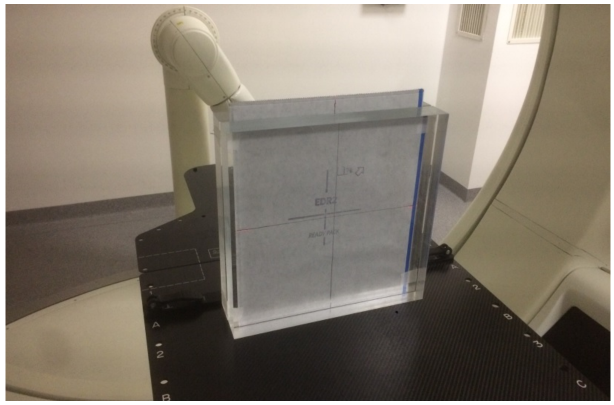

Fig. 1. Film setting for isocenter sphere measurement (gantry)

3 Result and Analysis

3.1 Isocenter Accuracy Measurement

Figure 2 shows the initial image by scanning the film. We use computer-aided image analysis based on MATLAB [4] for measuring isocenter sphere, which consists of three main steps.

1. Enhancing image contrast (Fig. 3a).
2. Fitting central axis of each strip (Fig. 3b).
3. Calculating smallest hitting circle based on line configuration of central axis (Fig. 3c and Fig. 3d).

Based on the smallest hitting circle coming from algorithm in Fig. 3d, we have calculated the diameters of isocenter sphere are 1.56 mm for gantry rotation and 0.54 mm for ring rotation.

3.2 FOV Accuracy Measurement

Figure 4a shows original image after scanning the both the film and Fig. 4b, as well as Fig. 4c, shows the light-field and irradiation field that we extract from the initial scanning image. We have detected the field corners and borders, as shown in Fig. 5.

By analyzing Fig. 5a and Fig. 5b, the developed program measures the border length of field and displays the results of calculations in the table, as shown in Table 1.

4 Conclusion

In isocenter accuracy assurance test, diameter of the gantry-rotation isocenter sphere is 13% excessive to expected value and in the ring-rotation isocenter sphere is 27% excessive. This implies slight offset of beam isocenter from gantry-rotation isocenter and ring-rotation isocenter. In the field correlation test, difference of edge length of actual irradiation field and light-field are within 2%, so, we can conclude that irradiation field conforms with to the light-field quite well.

Thus, in the paper, we have implemented and discussed the Linac quality assurance software of two important parameters.

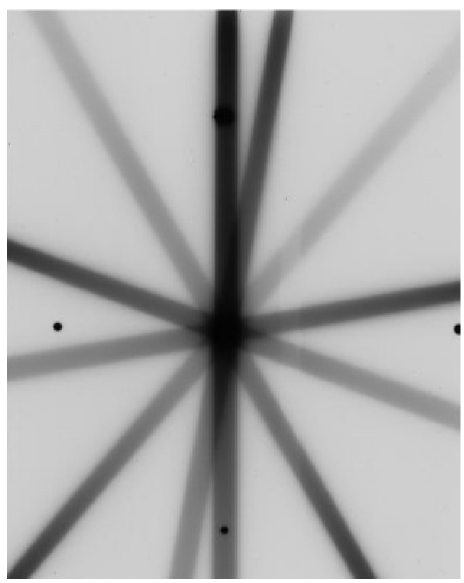

Fig. 2. Films of isocenter accuracy measurement (gantry-rotation)

Table 1. FOV detection result

Vertex coordinate (cm)	Border length (cm)	
Light field ($50 \times 50mm^2$)	Light field ($50 \times 50mm^2$)	Irradiation field ($50 \times 50mm^2$)
(7.92, 5.48), (12.79, 5.41), (7.85, 10.45), (12.90, 10.45)	4.87, 4.96 5.04, 5.03	5.02, 5.05
Light field ($100 \times 100mm^2$)	Light field ($100 \times 100mm^2$)	Irradiation field ($100 \times 100mm^2$)
(5.28, 14.41), (15.23, 14.33), (5.33, 24.24), (15.24, 24.19)	9.95, 9.83 9.91, 9.86	10.14, 10.13

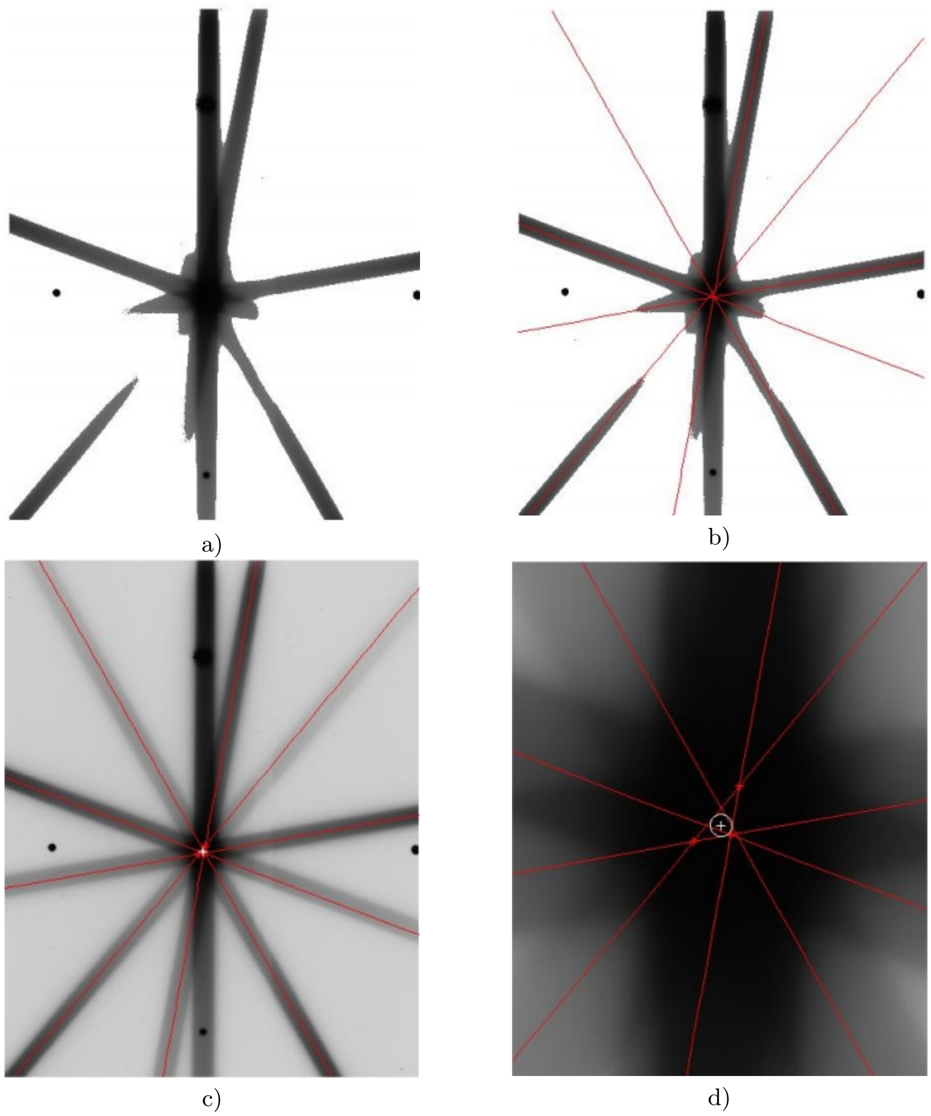

Fig. 3. Film Isocenter circle of gantry rotation after image processing; a) contrast enhancing, b) fitting central axis, c) the smallest hitting circle, d) the smallest hitting circle (zoom-in)

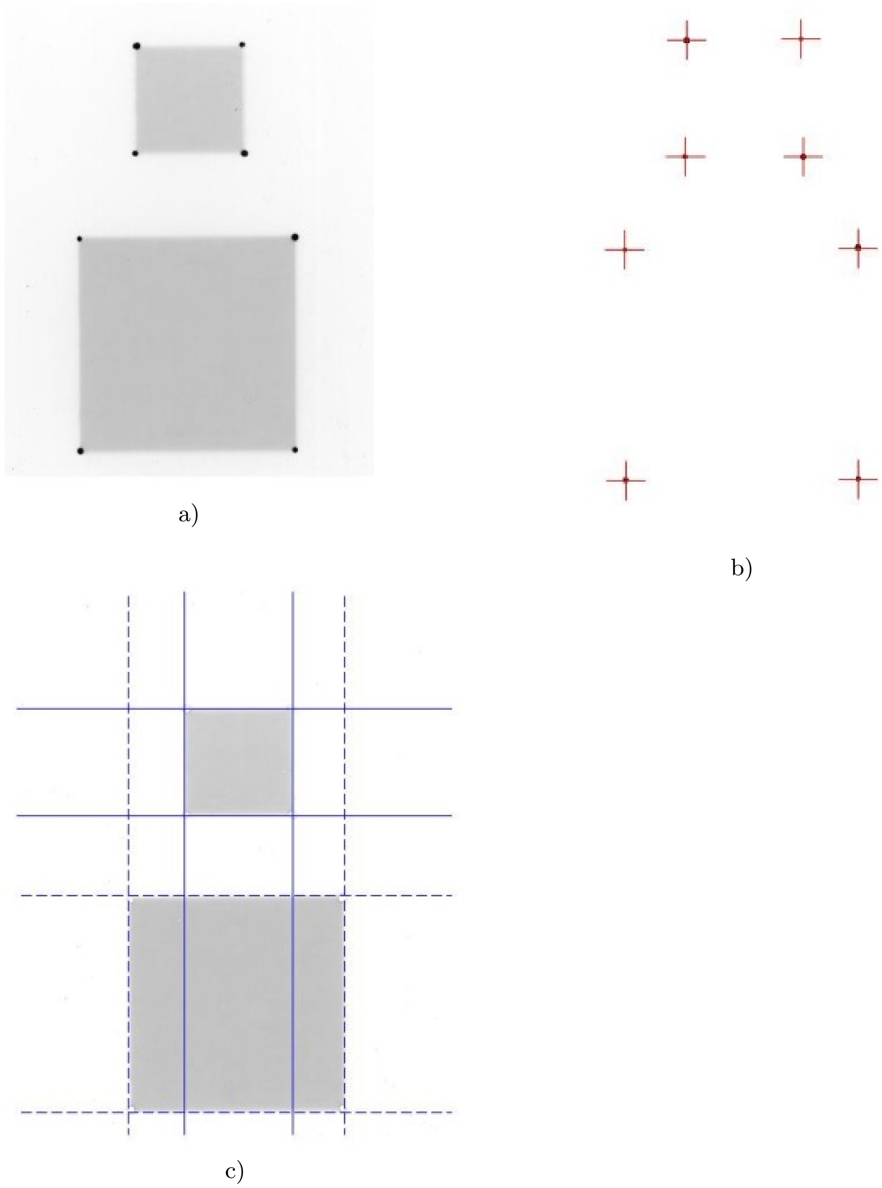

Fig. 4. Correlation of the light-field and irrradiation field; a) original film, b) extracted corner of light-field, c) extracted area of irradiation field

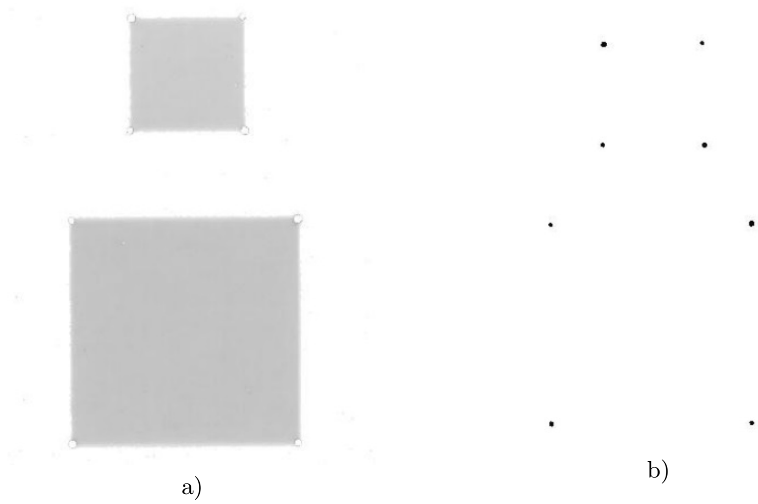

Fig. 5. Features detected from initial image: a) detected irradiation field borders, b) detected light-field corners

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