Estimation of energy dependency for Modulation Transfer Function of Digital radiography sensor by X-ray spectrum

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1. Introduction

The Modulation Transfer Function (MTF) of radiography system has been widely used for evaluating the resolution and contrast of detecting system. Recently, Digital radiography system and detector are propagated for clinical usage. A method for acquiring the MTF has been devised to accurately measure the MTF of digital X-ray systems. However evaluation method for MTF was not considered the current characteristic for X-ray system and detecting sensor. Therefore, this research was measuring the MTF for variable radiation quality condition by the simulation and experimental study for evaluating the energy dependency of MTF through the progress which was suggested by IEC-62220-1 (2000).

2. Methods and Results

2.1. Edge MTF Method

MTF was properties include spatial frequency and contrast. The Edge MTF method was the standard method of measuring the MTF by IEC 62220-1[1].

The standard geometry of acquiring the MTF by IEC 62220-1 was represented in Fig. 1. In this research, all the simulation and experimental geometry was same as IEC standard.

A digital image of the edge is processed to obtain the presampled MTF. Edge MTF method has been compared to the slit method using measurements on standard and high-resolution imaging plates of a digital storage phosphor (DSP) radiography system [2].

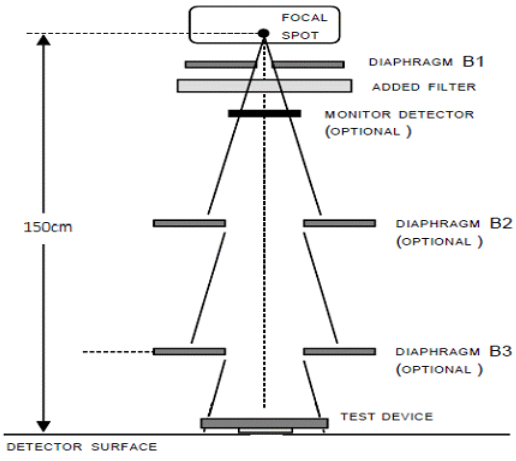

Fig. 1. Edge MTF Method Geometry (IEC-62220-1)

The edge method provides a convenient measurement of the presampled MTF for digital radiographic system with good response at low frequencies [3].

2.2. Radiation Quality

Radiation quality condition was very important factor for measuring the MTF. The radiation quantity has a variation by changing the tube voltage and current. IEC (International Electronic Commission) suggested the standard condition for physical evaluation in IEC-61267(1994)[4]. Table I showed the experimental condition of radiation quality and standard condition. SRS-78 software was used for acquiring the condition of radiation quality in simulation study.

Table Ⅰ: Experimental condition of radiation quality and Standard condition

	Radiation quality condition for Experiment and Simulation		Standard condition for IEC-61267
	Tube Voltage	Tube Current	Tube Voltage
RQA3	50 kVp	80 mAs	50 kV
RQA5	71 kVp	40 mAs	70 kV
RQA7	90 kVp	25.6 mAs	90 kV
RQA9	120 kVp	16 mAs	120 kV

2.3. Measurement of MTF (simulation and experimental Method)

The experimental study was performed by digital radiography system, Remote Radeye 200 sensor which was produced by Rad-icon imaging. Edge test device was used for acquiring the Edge spread function. The MTF result of each radiation quality was represented in Fig. 2. The MTF curve has similar trends by each RQA condition. However, the MTF result via this progress was not accuracy and many experimental error of X-ray system were generated. For this reason the simulation study for using Monte Carlo method, was also performed. In the simulation study, all condition of experiment was ideal and the result data were quantitatively calculated.

The simulation study was performed by MCNPX code (Los Alamos Laboratory). All the condition and

geometry was same as experiment condition. Fig. 3 showed the result of MTF for each RQA.

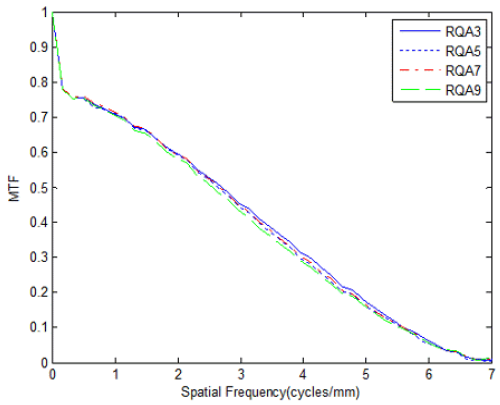

Fig. 2. MTF Curve for each RQA in Experiment

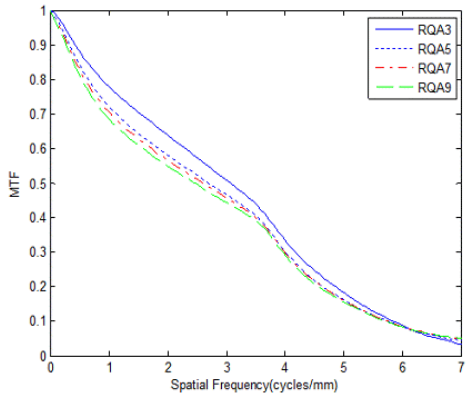

Fig. 3. MTF Curve for each RQA in Simluation Study

2.4. Significance test of MTF results

In simulation study, the MTF data of RQA3 had higher value than other MTF of RQA5, RQA7, and RQA9. The result of MTF data for RQA3 was verified by the Two-sample test (t-test). The verification result was represented in Table Ⅱ. If the p-value was lower than 0.05, it means that those data have a significance. However distinction between MTF data for RQA3 and other radiation quality was not significance. Furthermore the experimental MTF data has similar value by each RQA.

Table Ⅱ: The verification result for each RQA

	RQA3	RQA5	RQA7	RQA9
Average	0.3604	0.3356	0.3302	0.3227
variance	0.0955	0.0848	0.0815	0.0781
p-value		0.2612	0.2165	0.1609

3. Conclusion

The radiation quality affect to the image resolution and contrast. Considering the results for both studies, however, MTF was a little influenced by radiation quality. Because CsI(Tl) sensor which was used for the Digital radiography system has low energy K-absorption edge[5]. Therefore if the mean value of radiation energy was closed to the K-absorption edge of CsI(Tl) material, the effect of K-absorption edge was builded up. Although the influence of radiation quality was not decisive, we might consider the effect of radiation energy to the sensor material for calculating the MTF.

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