

A Simple Approach of Presampled Modulation Transfer Function Measurement Tested on the Phoenix Nanotom Scanner

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Abstract. In this paper presampled modulation transfer function of the 2D images obtained on the Phoenix Nanotom scanner was investigated with different measurement set-ups. Three parameters were chosen to investigate their influence on modulation transfer function: source-detector distance, tube current and binning mode. A simple method for modulation transfer function determination of digital imaging detectors from edge images was applied. The following results were achieved and briefly discussed: modulation transfer function improves with increase of the source-detector distance, slightly improves with increase of the current and remains constant for different binning modes. All measurements were carried out in University of Applied Sciences Upper Austria at Wels campus.

1. Introduction

In digital radiography as well as in tomography modulation transfer function (MTF) is one of the basic performance measures describing the signal transfer characteristics of the system as a function of spatial frequency [1, 2]. It can provide different information depending on the experiment results and measurement method applied. Therefore, it is used to investigate the capabilities of the new system, to find the weakest component of the scanner as a signal processing chain [3] or to investigate stability of the system and its behaviour while changing its parameters (as in this case), etc. It should be mentioned, that in this case the qualitative analysis was provided since the quantitative analysis demands rather complex positioning procedures [4]. See also the accuracy disclaimer section for additional information.

2. Materials and methods

In this study, presampled MTF was investigated which is a function of the signal transfer before the detector's sampling stage. In this approach the line profiles obtained from the image of slightly angulated edge are rearranged in a way to neglect the influence of the detector sample grid on the MTF. Therefore, the result function is independent on the signal patterns. Details of the image acquisition procedure as well as the calculation flow of presampled MTF can be found in the



corresponding articles [4, 5]. Although some details were not fulfilled due to lack of suitable positioning instruments, as will be described further. The test object used was a utility cutter made of steel approximately 0.5 mm in width (see figure 1).

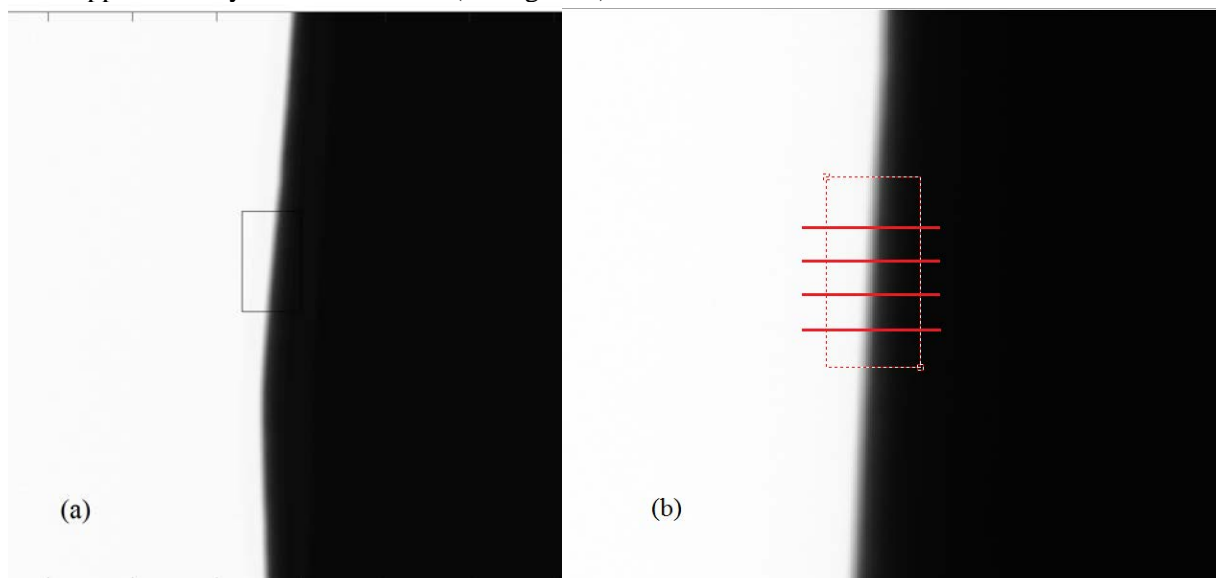


Figure 1. Example of the initial image with ROI for the MTF evaluation (a); linear profiles are obtained along the red lines (b).

During the investigation, a voxel size (VS) adjustment procedure was carried out using the ruby ball bar (see table 1). The error appeared to be relatively small and can be neglected for this particular task. Also we considered the error to be independent on the measurement parameters. It was decided then to use the voxel size stated by the acquisition software as the pixel size of the obtained 2D images.

Table 1. Parameters and results of the pixel size adjustment. SOD stands for source-object distance

Experiment	SDD (mm)	SOD (mm)	Stated VS (μm)	Measured VS (μm)	Nominal error (%)
1	500	50	5	5.075	1.5
2	200	20	5	5.04	0.8

3. Accuracy disclaimer

As it has been mentioned, it was not possible to provide positioning of the object needed for accurate quantitative analysis. For estimating of the inherent error the influence of two parameters on the result was estimated:

- Incline of the object in the detector plane (figure 2).
- Rotation of the object around the rotation axis of the drive (figure 3).

As can be seen from these pictures there is a significant influence of these parameters on the obtained MTF value, which implies a systematic error – apparently a bias to the worse MTF. This makes accurate quantitative analysis impossible. However since the object positioning was constant during the experiments (except for the SOD) it is possible to provide qualitative analysis.

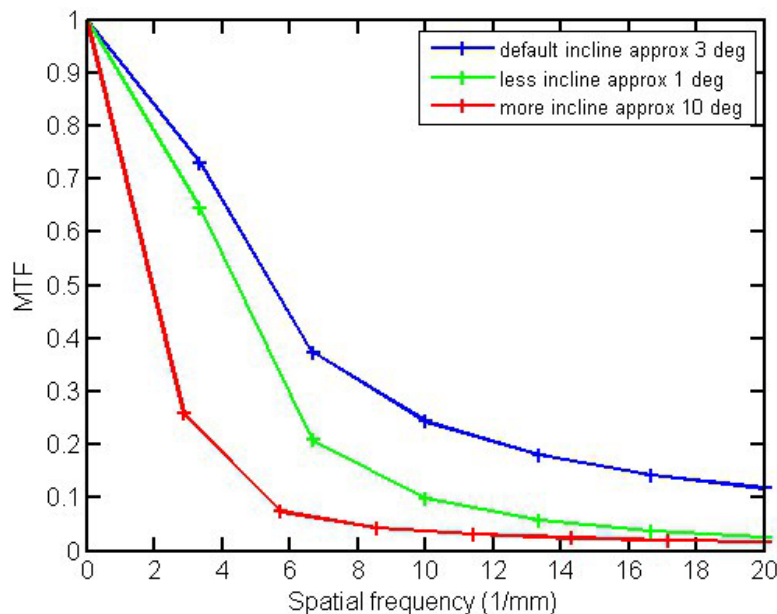


Figure 2. MTF curves for different incline of the test object in the detector plane: 3° (default) – blue, 1° – green, 10° – red.

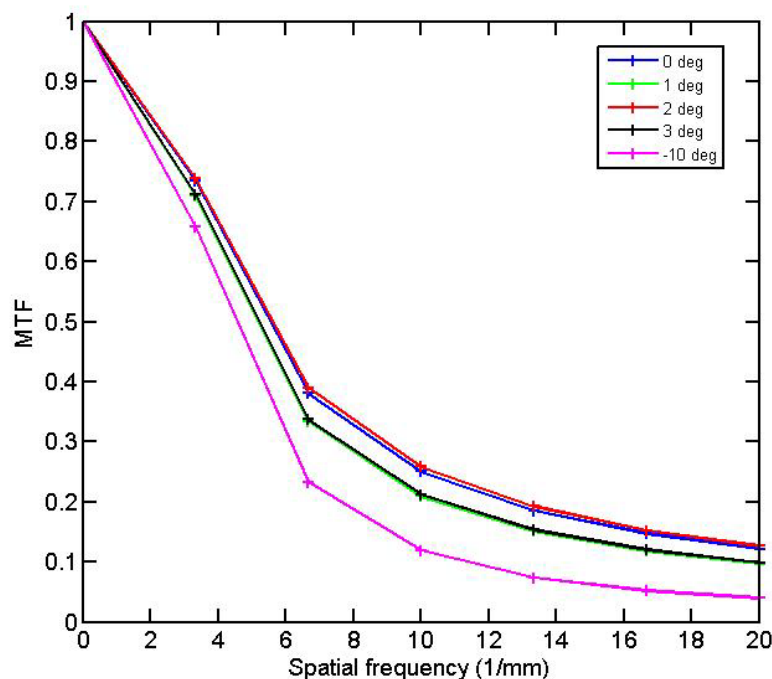


Figure 3. MTF curves for different rotation of the object around the rotation axis of the drive: 0° (default) – blue, 1° – green, 2° – red, 3° – black, -10° – purple. The highest values of MTF on 0 and 2 degrees are due to non-uniform shape of the cutter.

4. Experiments

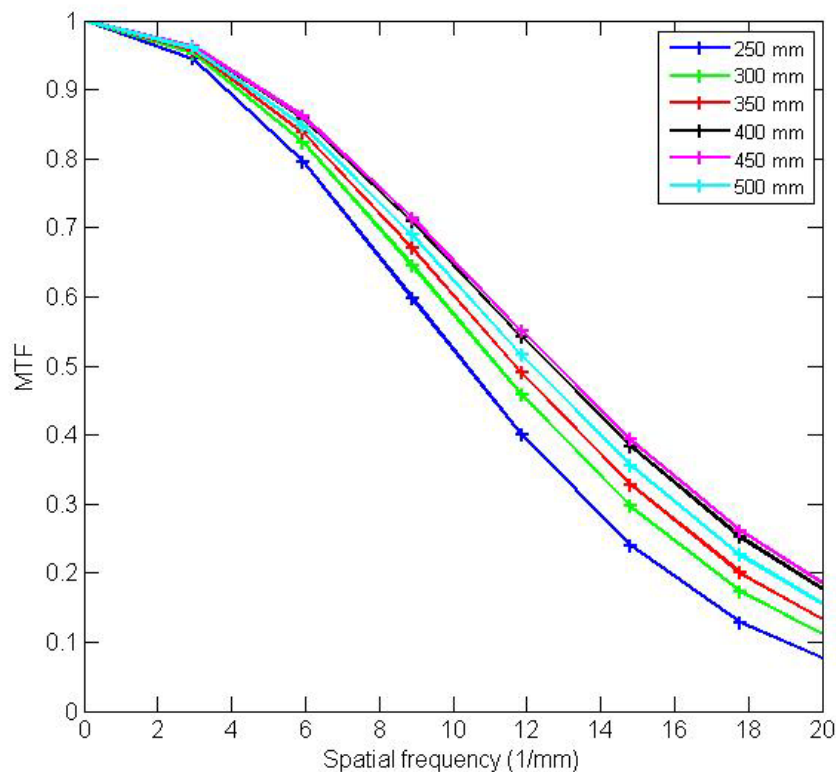
All experiments within one group were provided in random order to avoid any potential disturbances due to unknown factors. Averaging of 50 projections was used to improve the signal-to-noise ratio.

4.1 SDD impact study

In this case only the SDD was considered as a variable. Source-object distance (SOD) and integration time were changed for every experiment to make the geometric magnification and the mean grey value to be the same. In case of grey values that was made approximately. Any other parameters remained the same (see table 2). Results of measurement are shown on figure 4.

Table 2. Parameters for the SDD impact study

Target	U (kV)	I (uA)	Binning	V (um)		
Molybdenum	45	370	2x2	5		
Experiment	1	2	3	4	5	7
SDD (mm)	200	250	300	350	400	500
SOD (mm)	10	12,5	15	17,5	20	25

**Figure 4.** MTF curves for different SDD values: 250 mm – blue, 300 mm – green, 350 mm – red, 400 mm – black, 450 mm – purple, 500 mm – light blue. MTF improves along with increase of SDD.

4.2 Study of the tube current impact

In this case only the current was considered as a variable. Integration time was changed for every experiment to make mean grey value approximately be the same. Any other parameters remained the same. Mode 1 was used since it has been stated by the manufacturer that the tube power doesn't influence the focal spot size. Therefore, no apparent decrease in resolution should be expected as the current changes. We used different current values (see table 3) and have found that MTF even improves slightly when current increases (see figure 5).

Table 3. Parameters for the current impact study

Target	U (kV)	SDD (mm)	SOD (mm)	binning	VS (um)
Molybdenum	80	300	12	1×1	2
Experiment	1	2	3	4	5
I (uA)	180	150	120	90	60

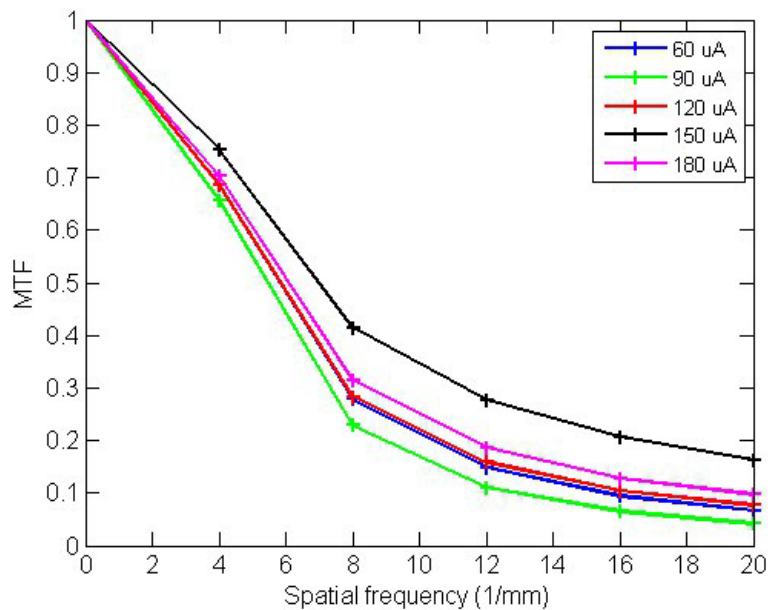


Figure 5. MTF curves for different current values: 60 uA – blue, 90 uA – green, 120 uA – red, 150 uA – black, 180 uA – purple. MTF slightly improves along with increase of the tube current.

4.3 Study of the binning mode impact

In this case only the binning was considered as a variable. SOD and integration time were changed for both experiments to make geometric magnification to be the same and the mean grey value to be the same approximately. Any other parameters remained the same (see table 4). As shown on figure 6, binning does not influence on MTF noticeably.

Table 4. Parameters for the binning mode impact study

Target	U (kV)	SDD (mm)	I (uA)	VS (um)
Molybdenum	80	300	150	2
Experiment	1	2		
Binning mode	1×1	2×2		
SOD (mm)	12	6		

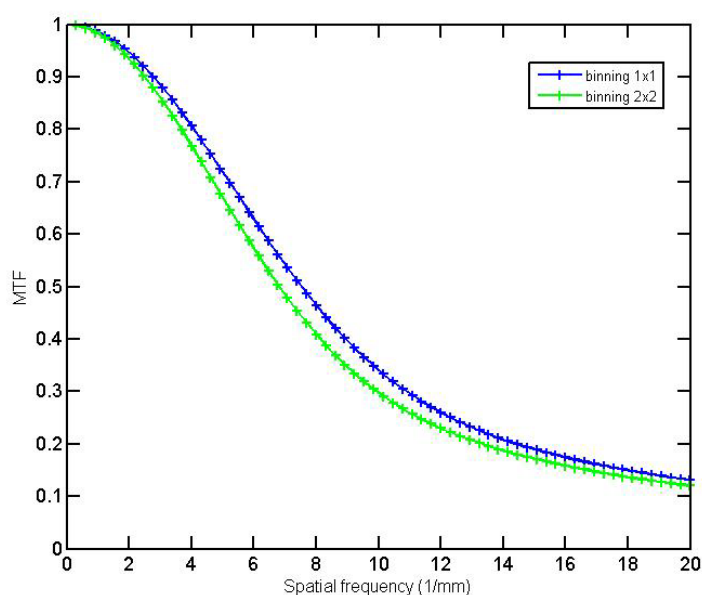


Figure 6. MTF curves for different binning modes: binning 1×1 – blue, binning 2×2 – green. MTF varies slightly with change of the binning mode.

5. Discussion

To conclude here are the main results of these experiments and possible explanations:

- 1) MTF increases with the SDD becoming greater. The effect is more pronounced for higher spatial frequencies. The possible reason is increase of scattering influence along with decrease of SDD.
- 2) Higher tube current slightly improves MTF. This apparently proves manufacturer's claims that mode 1 provides focal spot more or less independent of the tube power. Therefore the reason for the slight improve of the MTF with increase of the current should have something to do with non-linear response of the detector for different integration times.
- 3) MTF remains almost the same for different binning modes. The slight decrease in the resolution for the binning mode 2×2 is probably due to the higher scattering because of the less SDD value.

Acknowledgments

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