Temporal MTF: Validation of the Independence of the Estimates from the Linear Velocity in the Rotating Blade Method

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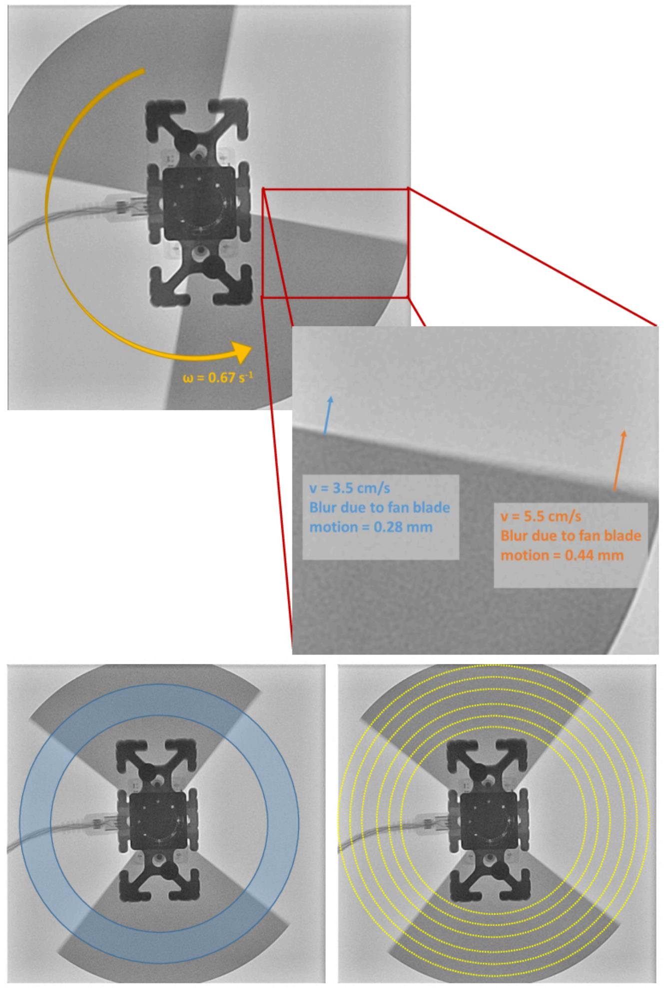
INTRODUCTION

- High temporal performance of cardiac catheterization fluoroscopic systems is critical to prevent blurring due to anatomical motion from degrading image quality.
- A method to evaluate system temporal modulation transfer function (TMTF) using a rotating fan-blade phantom has been previously presented.
- **The goal of this study was to ensure the validity of the constant angular velocity approach, which, in contrast to the translating edge method, includes a range of linear velocities, creating differential blurring along the fan-blade phantom edge.**

METHODS

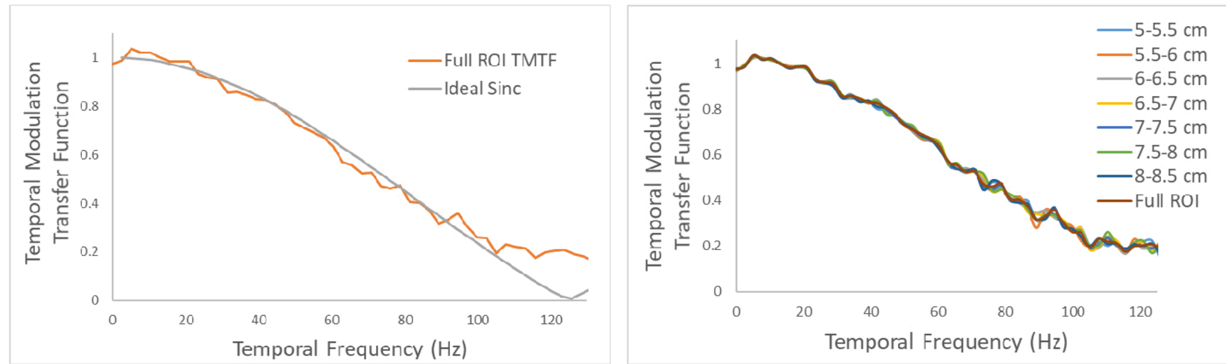
- Images for this study were acquired using a Philips Allura FD10 system used for electrophysiology (EP) applications. This system was selected for its short <10 ms pulse width cine acquisitions.
- The average exposure per frame was measured to be 0.12 mR/frame
- Cine images of the static phantom were acquired to determine the spatial MTF. Images of the phantom rotating can be used to determine the spatio-temporal MTF, though these components are separable.
- **Previous TMTF studies with this phantom have utilized a single broad circular ROI, encompassing a wide range of linear velocities.**
- **This study employed seven narrower concentric ROIs, spanning the usable range of the phantom edge.**
- Narrow ROIs limit the range of linear velocities included in each measurement. The phantom rotates at 40 rpm effective, corresponding to linear velocities ranging from 3.5 – 5.5 cm/s in the usable space on the phantom blade.
- Results were examined for velocity-dependent deviations.
- This study expanded beyond the inner and outer boundaries previously used and found that there was no significant change in TMTF at points near the phantom motor (center) or near the outer edge of the fan blade phantom.



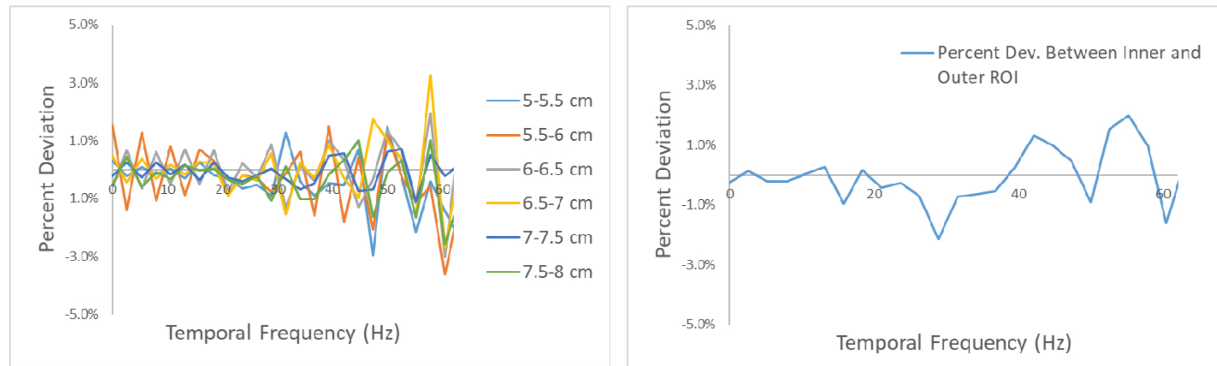
TOP: Diagram displaying the differential blurring along the fan blade edge due to motion. BOTTOM: Images contrasting the original, wider ROI used for TMTF determination, against the smaller sub-ROIs used for this study.

RESULTS

- Approximately 40 cine frames were averaged for each TMTF measurement
- All measured TMTFs exhibited the expected sinc function shape, with bounce point consistent with the x-ray pulse width.
- Deviations of the TMTF from the ideal sinc function near the first bounce point are due to aliasing from high temporal frequencies.
- **TMTFs measured from all seven sub-ROIs demonstrated minimal deviation from each other, with average absolute percent deviation of 1.3% between the inner- and outer-most ROIs up to the Nyquist frequency.**
- **There was good agreement shown between the TMTFs determined from smaller ROIs and the large full-width ROI; the average percent deviation between each narrow ROI and the large ROI was less than 1%.**



LEFT: The TMTF determined from the full width ROI plotted with to the sinc function based on x-ray pulse width. RIGHT: All TMTFs determined from narrow sub-ROIs plotted with the TMTF determined from the full ROI plotted out to the first bounce point at 125 Hz.



LEFT: The percent deviation between each narrow sub-ROI and the conventionally determined TMTF with broader ROI, plotted out to the Nyquist frequency determined by pulse width. RIGHT: A plot of the percent deviation the inner-most and outer-most sub-ROIs. The plot only shows the two most extreme locations for simplicity. The small deviation between the two suggests the velocity-independence of this method.

CONCLUSIONS

- **The consistency of TMTFs derived from sub-sections of the phantom moving at differing linear velocities confirms the validity of using a constant angular velocity approach to estimating the TMTF.**
- This method represents a readily implementable tool for monitoring temporal image quality with the distinct advantage of acquiring as many frames as desired without needing to reset a phantom.
- The temporal resolution information gained from this method makes it a valuable tool that fits into a suite of advanced metrics that can be employed for comprehensive fluoroscopic system comparisons.

REFERENCES

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