Assessment of the detectability of a moving guide wire in fluoroscopically-guided procedures using a mathematical model observer

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•Objective

Fluoroscopically-guided procedures are among the most irradiating medical interventions. A fair amount of pressure is thus put on reducing patient dose. The downside is a potential loss in image information content. To our knowledge, there is no existing quantity able to properly assess the visibility of moving structures in fluoroscopic images. This work proposes a new method to measure image quality using a clinically relevant detection task in dynamic conditions using a mathematical model observer[a].

•Materials and methods

Our test object was a 3 mm thick and 250 mm wide PMMA square plate, with a 1 mm deep grove along one of the diagonals. The grove was used to straighten a 0.014” coronary guide wire (fig. 1).

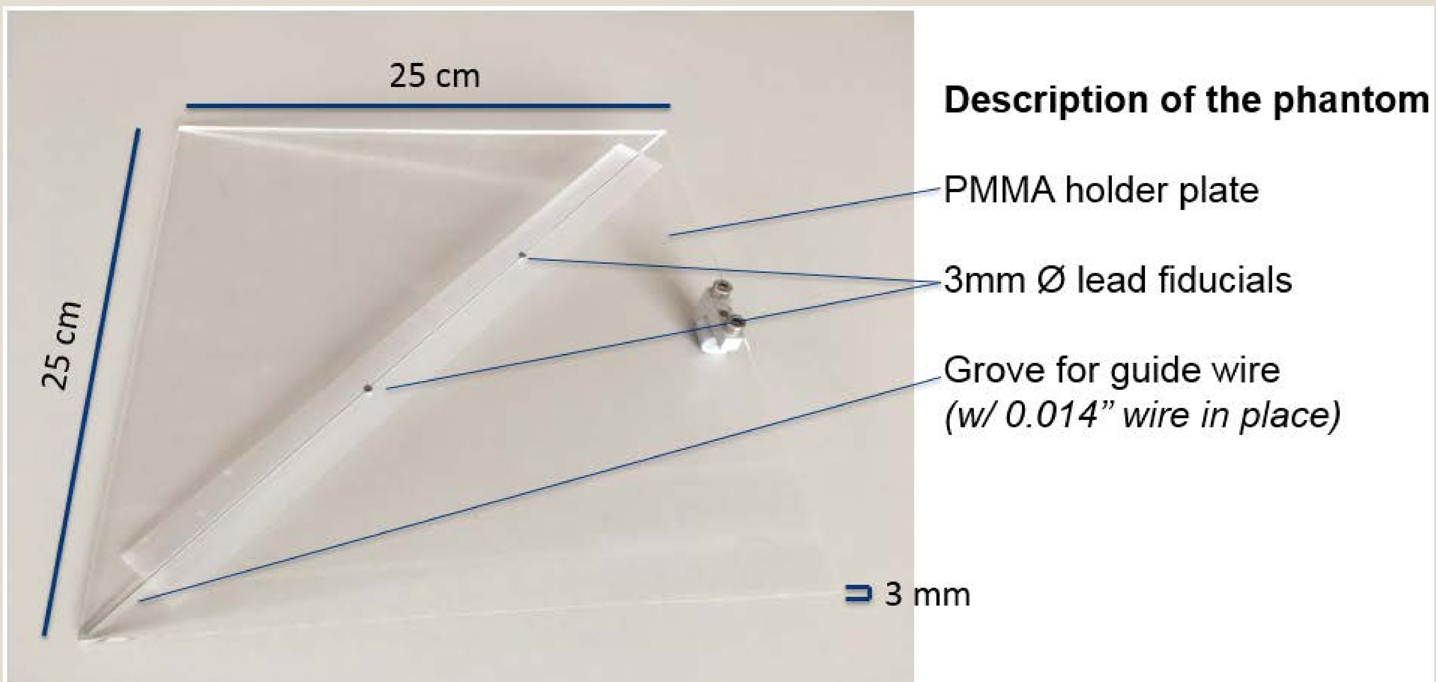

Figure 1: PMMA plate supporting a 0.014” guide wire.

The plate was attached to a dedicated motion simulation engine (QRM Sim 2D, Moehrendorf, Germany) using a cantilever, allowing the plate to move at velocities and motion amplitudes representative of coronary arteries. A series of 2.5 and 5 cm thick PMMA slabs, stacked around the test object and separated using Lego® bricks, simulated a patient thickness of 20 cm while keeping the guidewire at the geometric centre of the stack (fig. 2).

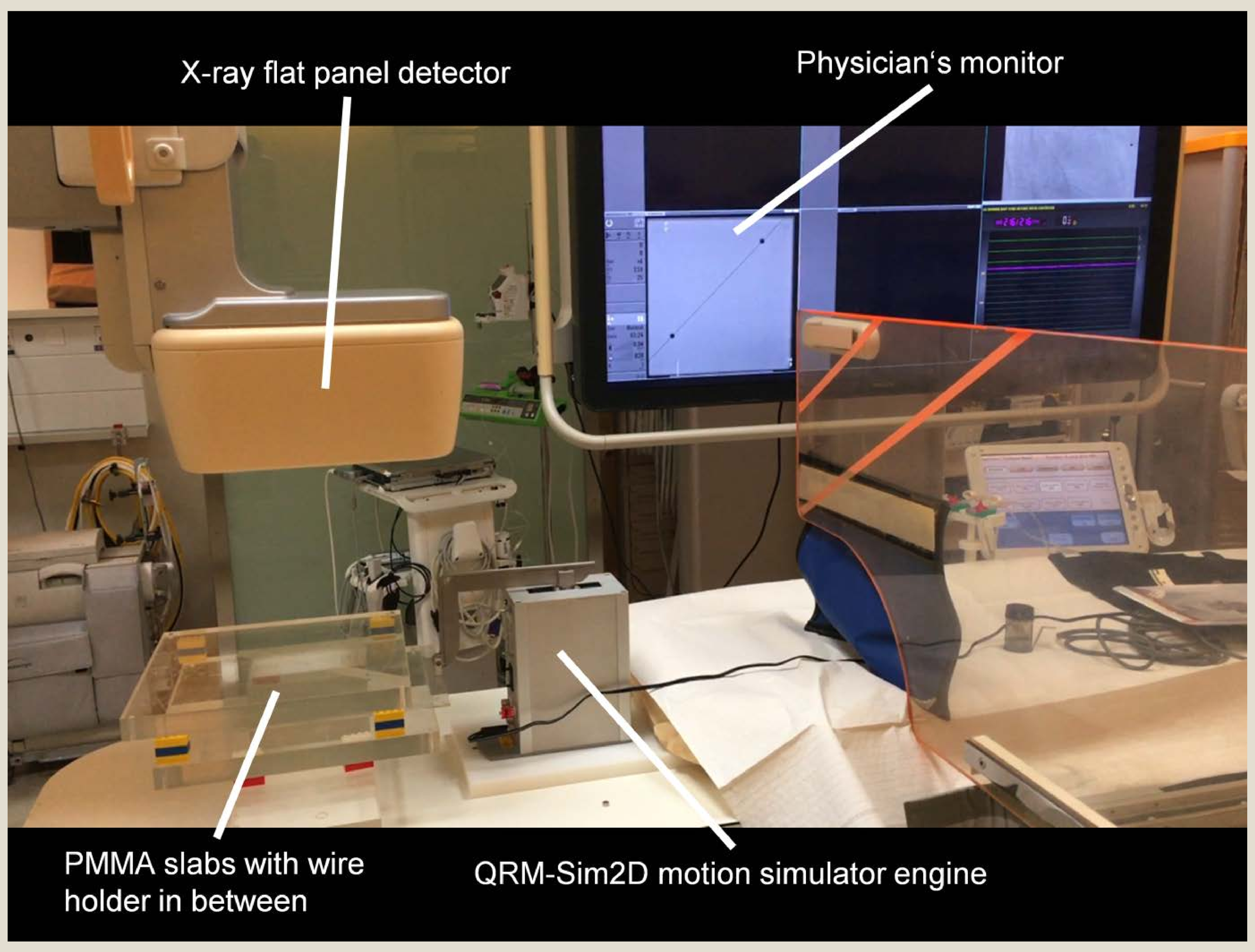

Figure 2: Experimental setup: The motion simulation engine, with the guide wire holder, were placed at the isocenter of the fluoroscopy unit. PMMA plates stacked around the holder and separated using Lego® bricks simulated a patient body thicknesses of 20 cm.

Images were acquired using the unit’s pre-defined fluoroscopy quality levels (low, medium and high) on two different devices: One dedicated for interventional cardiology (IC – Philips AlluraClarity FD10), the other for a broader purpose range (Philips Veradius Neo).

From the images, several hundreds of ROI were extracted, either in the homogenous zones (signal-absent images), or along the guidewire (signal-present) – between 400 and 900 combined, depending on the field of view and image pixel matrix. For this purpose, lead fiducials placed along the guidewire allowed for its non ambiguous localisation, even for low dose acquisitions (fig. 3).

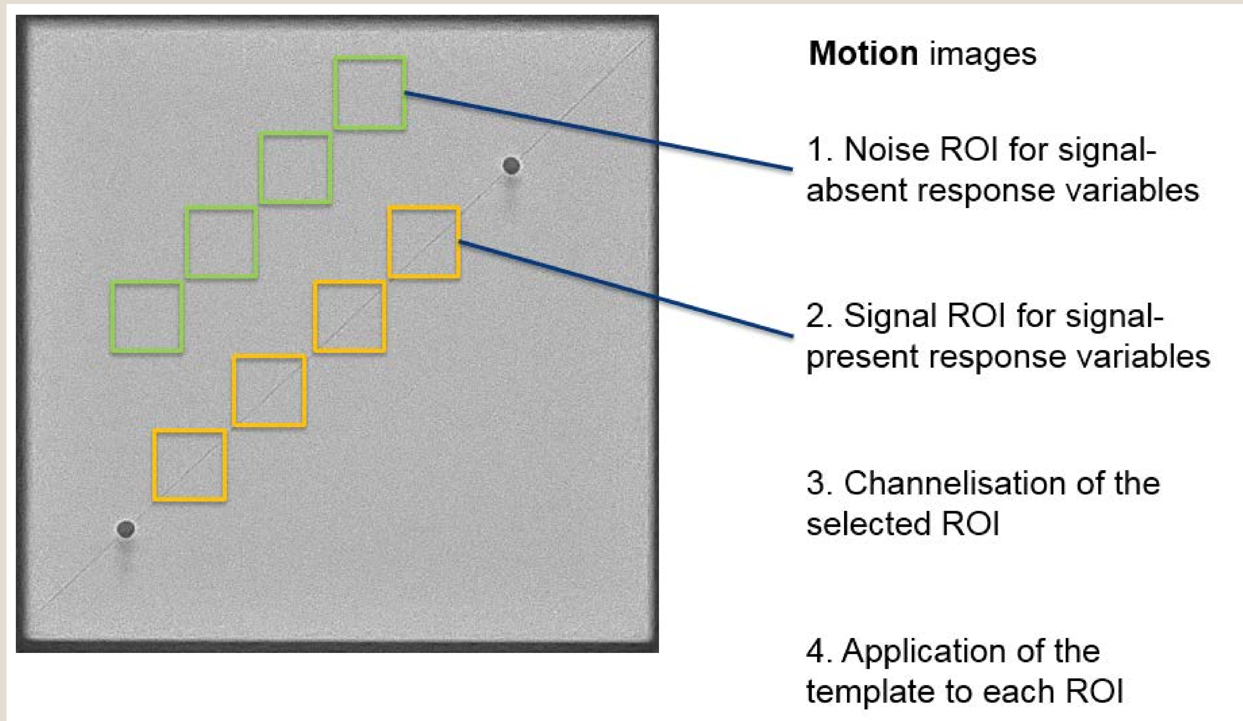

Figure 3: Extraction of the signal-absent and signal-present ROIs on the acquired images, using the lead fiducials as non-ambiguous fiducials of the guide wire’s position.

A decision variable λ was calculated on each signal-absent and signal-present image using a channelized Hotelling model observer (CHO) with eight Gabor channels[b]. Both signal-present and signal-absent λ distributions were combined in a histogram, and the signal-to-noise ratio (SNR) between both distributions was taken as the figure of merit (FOM) of the guide wire detectability (fig. 4).

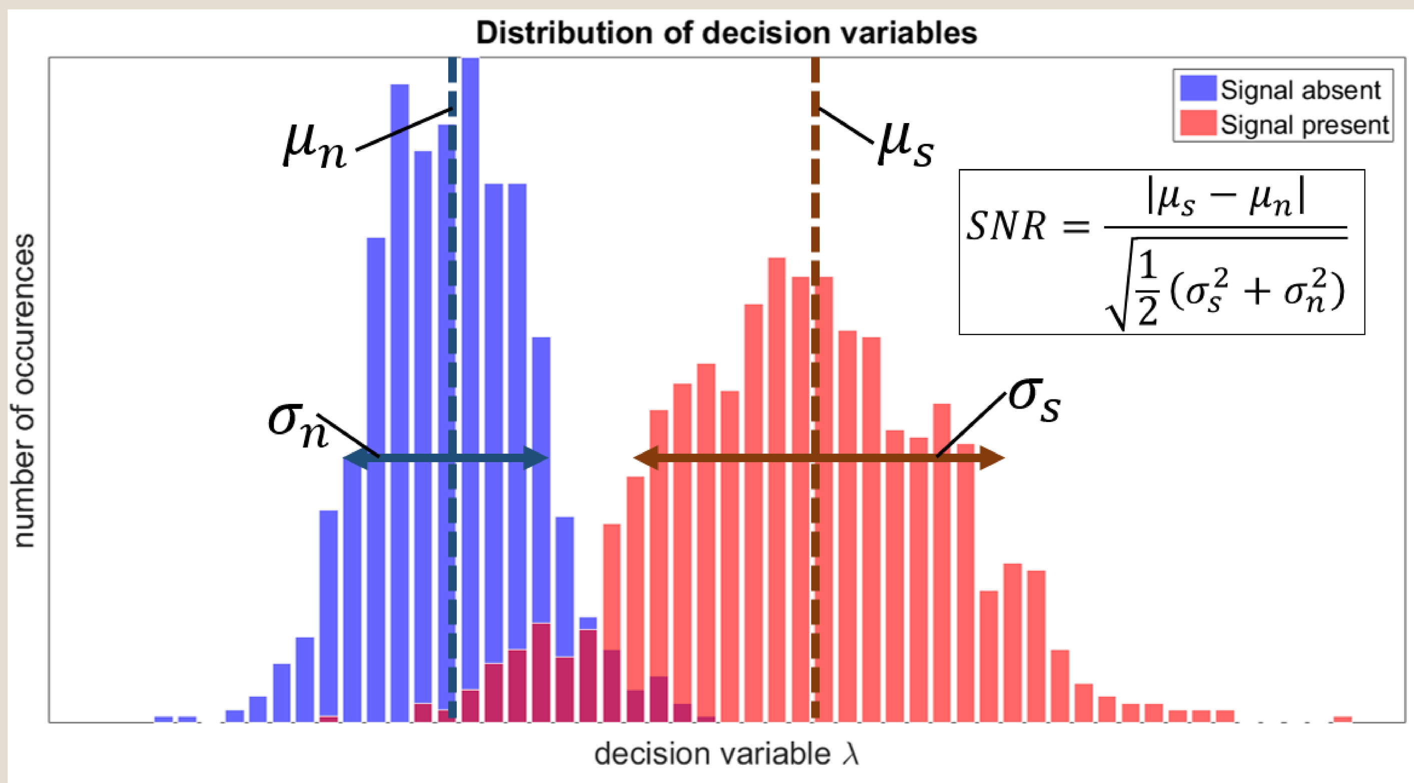

Figure 4: The signal-to-noise ratio (SNR) between the signal-absent and signal-present response variables was taken as the figure of merit (FOM) of the guide wire detectability:

•Results

Unit	Quality setting	PMMA entrance dose rate [mGy min^{-1}]	SNR
Philips AlluraClarity FD10	Low	7.7	3.5
	Medium	12.2	4.1
	High	28.6	4.9
Philips Veradius Neo	High	11.5	2.0

•Conclusion

We have shown the feasibility of using a CHO to assess dynamic image quality based on a clinically relevant task, i.e., the detection of a coronary guide wire. Further steps will include the fine tuning of the model to match with human observer results, to define a threshold SNR under which image quality is deemed insufficient.

a) Barrett, H. H., Myers, K. J. and Rathee, S. (2004), *Foundations of Image Science*. Med. Phys., 31: 953-953. doi:10.1118/1.1677252
b) *Implementation of a channelized Hotelling observer model to assess image quality of x-ray angiography systems*, C. P. Favazza, K. A. Fetterly, N. J. Hangiandreou, S. Leng, B. A. Schueler, J Med Imaging (Bellingham). 2015 Jan;2(1):015503. doi: 10.1117/1.JMI.2.1.015503