

Determination of limiting values for CDMAM images with structured backgrounds

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Summary

For many years image quality in mammography has been assessed by detecting objects in homogeneous backgrounds. But especially in mammography the anatomic background created by glandular tissue influences the detectability of lesions enormously. Therefore, it appears to be necessary to use anthropomorphic phantoms with structured (anatomical) backgrounds which mimic the clinical situation more realistic and increase the validity of such tests.

For the CDMAM phantom limiting values are defined for tests featuring homogeneous backgrounds.

First, we determined the relationship between CDMAM threshold thicknesses by human readouts of CDMAM images with structured and homogenous backgrounds. To validate these results, we compared the resulting threshold thicknesses with predictions resulting from a non-prewhitening matched filter (NPW) observer model. The model was extended by adding an eye filter (VTF) which has no DC response and is referred to as the NPWE model. Its detectability index d' for the signal-known-exactly (SKE) case with Gaussian, stationary noise and backgrounds is given by (Burgess 2001)

$$d' = \frac{\sqrt{2\pi}C \int_0^\infty S^2(u)MTF^2(u)VTF^2(u)udu}{\sqrt{\int_0^\infty S^2(u)MTF^2(u)VTF^4(u)NNPS(u)udu}}.$$

First, we determined the relationship between CDMAM threshold thicknesses and the detectability index d' . Another linear regression was estimated by calculating the detectability index for homogeneous and structured backgrounds. These relationships can then be used to transform threshold thicknesses to images with structured backgrounds.



From the human read-outs the limiting values resulted to $2.39\ \mu\text{m}$ (for gold discs of 0.1mm , compared to $1.68\ \mu\text{m}$ given by the standards), 0.49 (diameters 0.25 mm ; $0.35\mu\text{m}$ standard), $0.19\ \mu\text{m}$ (0.5 mm diameter; $0.15\mu\text{m}$ standard) and $0.13\ \mu\text{m}$ (diameter 1.0 mm , $0.09\ \mu\text{m}$ standard). The Coefficient of determination R^2 of the linear logarithmic relationship between detectability index and CDMAM threshold thickness was 0.936 . The parameters of the linear function were in good accordance to literature (Monin 2011). The detectability index for the structured background was found to be independent of dose. Therefore, the experimental results could not be confirmed by the theoretical derivations. It revealed that using a structured background resulted in dose-independent normalized noise power spectra (NNPS), because noise arising from structured background was a factor of about 1000 higher than quantum noise.

Nevertheless, the presented factors between homogenous and structured backgrounds should be of interest for future determination of limiting values for phantoms with anatomical backgrounds. Although it is not clear why the NPME failed, the application of a Hotelling observer could give an alternative approach.