Towards an anthropomorphic model observer for spiculated masses

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Rationale

As compared to other abnormalities in mammograms, spiculated masses (SpMs) are more likely to be malignant. This motivated prior research on computer-aided detection of SpMs[1,2], using Hough or Radon transforms to detect the spicules, and/or using alternative image analysis[3,4,5]. However, we found no prior study in the literature addressing the perception or detection of SpMs by human observers. An anthropomorphic model observer for SpMs may be used in virtual clinical trials for optimization of medical imaging and visualization systems.

Methods

We adapt Barten's model[6] for visibility of sinusoidal patterns to the anthropomorphic detection of SpMs, consisting of a central mass, assumed to be generally round and at a known location, from which several spicules emanate, as follows. We theorize that the detection of a SpM is equivalent to the detection of its central mass (i.e., central mass contrast with respect to its surround should exceed a certain threshold) *and* the detection of several spicules. The latter is modeled by angularly unwinding the concentric rings surrounding the central mass and inspecting whether there is enough contrast for visibility of each spicule in several adjacent rings. By allowing small shifts between the visible activities detected in different rings, the non-radial spicules can be also detected. Note that the viewing distance may be considered optimal for viewing the central mass or the spicules but not both. Validation will be conducted by gauging the visibility of SpMs by humans[7] and comparing those against the detection probabilities produced by the model observer.

Results and conclusion

Our preliminary results are promising. This is a work in progress and it is too early to draw a conclusion. For example, the validation against human observers (to be performed) will most likely reveal that the method of combining the results of spicule detection and central mass detection into a single SpM detection probability depends on the specific human observer to be modeled and the viewing condition (e.g., viewing distance or display contrast) which determine the amount of detection-related information in the visual elements of the SpM (i.e., each of the spicules and the central mass).

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[1] Karssemeijer, N. (2002). Detection of Masses in Mammograms In R. N. Strickland editor, *Image-Processing Techniques for Tumor Detection* (pp. 187-212). New York, NY: Marcel Dekker.

[2] Sampat, M. P., Markey, M. K., Bovik, A. C. (2005). Computer-Aided Detection and Diagnosis in Mammography In A.C. Bovik editor, *Handbook of Image and Video Processing* (pp. 1195-1217). Burlington, MA: Elsevier.

[3] Muralidhar, G. S., *et al* (2010). Snakules: A model-based active contour algorithm for the annotation of spicules on mammography. *IEEE Transactions on Medical Imaging*, *29*(10), 1768-1780.

[4] Sampat, M. P., Bovik, A. C., Whitman, G. J., & Markey, M. K. (2008). A model-based framework for the detection of spiculated masses on mammography. *Medical physics*, *35*(5), 2110-2123.

[5] Krylov, V. A., & Nelson, J. D. (2014). Stochastic extraction of elongated curvilinear structures with applications. IEEE Transactions on Image Processing, 23(12), 5360-5373.

[6] Barten, P. G. (1999). *Contrast sensitivity of the human eye and its effects on image quality* (Vol. 72). SPIE press.

[7] Avanaki, A., Espig, T., Xthona, A., & Chesterman, F. (2017). How does display brightness affect lung CT reading? SPIE MI live demo workshop.