Mathematical observers applied to breast tomosynthesis.

I. Diaz[1], P. Timberg[2], C. Abbey[3], M. Eckstein[3], F. R. Verdun[1], C. Castella[1], F.O. Bochud[1]

[1] University Institute for Radiation Physics, DUMSC, CHUV and University of Lausanne, CH-1007 Lausanne, Switzerland
[2]Department of Medical Radiation Physics, Lund University, Malmö University Hospital, Malmö, Sweden
[3]Dept. of Psychology, University of California, Santa Barbara, CA, USA 93106-9660
mail: francois.bochud@chuv.ch

Introduction

For breast tomosynthesis (BT) there is a large space of acquisition parameters that can be optimized both in terms of image quality and dose from the point of view of radiation protection. To attempt this optimization only using human observers would be very costly and time-consuming. Model observers have been developed to mimic the response of humans in order to test on much larger sets of images in a shorter time than would be possible otherwise. The aim of this study was to adapt existing model observers to be used with irregularly shaped breast tomosynthesis (BT) signals.

Material and Methods

This paper expands upon a previous study where different circularly symmetric model observers were used to compare digital mammography to BT. The present study is based on a more realistic version of the signal considered at three different sizes (from microcalcification to tumor masses) and three different contrast levels.

In the previous study, we observed that the channelized Hotelling observers (CHO) with Gabor and Difference-of-Gaussians channels were always outperformed by the human observers. In this study, we decided to modify the channels in order to accommodate the fact that the targets were not radially symmetric. Instead of treating the channels as a simple linear templates, we calculated them as filters which were then convolved with the target profile. These were then tested on the signals which were embedded in real breast tomosynthesis backgrounds.

Results

Once this modification was made, the model observers outperformed the human observers in 4-AFC trials by at least a factor of 1.5 in every case except for the smallest one, that of an observer with channels not sufficiently tuned to the high spatial frequencies necessary to detect microcalcifications. The very high performance obtained was degraded by the addition of internal noise to match the human performance.

Discussion

Getting model observer performance to exceed that of humans is the first step in obtaining observers which can be confidently used on trials with vast numbers of parameter variations. These CHOs, better adapted to irregular signals, combined with the information gained from adding more sizes and contrasts than previously available will aid in refining the model observers which are to be used in automating the optimization of BT acquisition parameters.

References

[1] C. Castella, et al : Masses detection in breast tomosynthesis and digital mammography: a model observer study: Proc. SPIE Medical Imaging, 2009
[2] Ruschin, M, et al: Improved in-plane visibility of tumors using breast tomosynthesis: Proc. SPIE Medical Imaging, 2007
[3] Eckstein, M; Abbey, C; Bochud, F: A practical guide to model observers for visual detection in synthetic and natural noisy images: Handbook of Medical Imaging. Volume I. Physics and Psychophysics, 2000