4. Discussion and future work

The measurement component of an object provides information on how well this object is transmitted through the imaging system. Comparing the measurement component in Fig. 6 to its object in Fig. 5, we can see that the information received in the image plane is not complete. This illustrates the fundamental limit of the acquisition process, and serves as an estimate of the best reconstruction that could be achieved. We can also see that the measurement component looks a lot like the object, but that it also borrows traits from the projection in Fig. 7. This reflects the small angle used in tomosynthesis and its effect on the results. The reconstruction, while given in 3D, is in many ways an improved projection or a projection with some separation of information into different layers. It is not the full 3D reconstruction that could be achieved from e.g. tomography.

It is also becoming evident that there is a lack of three-dimensional models of the breast tissue. Statistical models for the normal breast, such as the clustered lumpy background [23], are made for 2D and not for 3D. Since mammography has been the dominating investigation method, it has simply been sufficient to work only on the 2D projection through the breast. Extensions to 3D are either intuitive and lack the statistical back-up required for a systematic study, like the example presented in this paper, or advanced models designed to produce one really good phantom and not the large number of samples required for a statistical study. There is need for a model of the breast tissue that has the same statistical properties as experimental images in 3D but also in its 2D projections, that looks similar to experimental images in 3D but also in its 2D projections, and that allows for generation of numerous realizations. Strong candidates at the moment are a more sophisticated extension of the clustered lumpy background [23], the threshold model by Abbey and Boone [25], or the breast phantoms by Zhang et al. [26]. The example object in Fig. 5 is sufficient as an illustration of the SVD method, but is not interconnected enough for a real slice through breast tissue.

The next step would be to use the SVD of a more realistic breast tissue model in an image-quality study, including the effect of noise. The SVD model is particularly suitable for this since the statistics of the object background are relatively easily transferred to the image through the use of characteristic functionals [11, Sec. 8.5.3]. The SVD singular functions can also be used as channels for a channelized observer [27]. This allows for many comparisons, for example how or if the detection seems to improve with tomosynthesis compared to mammography, or how the SVD method compares to other reconstruction algorithms.

5. Conclusions

The mixed continuous and discrete operators of a tomosynthesis system have been derived from the Boltzmann equation, and used to develop an analytical singular-value decomposition of a tomosynthesis system. In combination with numerical calculations, it provides the measurement component of any object, where object refers to the breast tissue. The measurement component of an example object has been presented. Although the example object is not truly realistic, interesting information on the tomosynthesis process and its effects on reconstruction have been found. Future prospects involve more realistic 3D breast tissue models, and an image-quality study involving a channelized Hotelling observer.

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