Microwave-based Breast Imaging: Existing Evidence, Challenges, and Future Paths

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Introduction

- Breast microwave imaging (BMI) uses **low-power microwave signals** for tumour detection
- **Several clinical trials have been performed** [1], the largest used 225 patients
- Preliminary estimates of the diagnostic performance have been presented using data from clinical trials

Methods

- A **scoping review** was performed
- Studies identified using the Scopus search engine with search terms: “breast” AND (“microwave” OR “radar”) AND (“imaging” OR “detection” OR “sensing”)
- **184 studies** were identified for inclusion

Diagnostic Performance

- **Sensitivity** estimates: 63-100% (n = 11)
- **Specificity** estimates: 20-63% (n = 4)
- Majority of research used *a priori* information in diagnosis

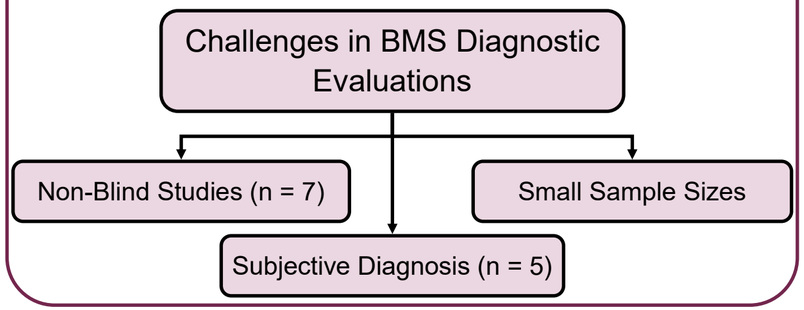


Image Quality Analysis

- Image quality analysis in BMI focuses almost exclusively on **contrast** (ex: signal-to-clutter ratio)
- **Limited accuracy analysis** has been performed (only the tumour localization error)
- A ***hot-spot*** artifact, resembling a tumour-response, was observed in several published articles without discussion (example shown in Fig. 1)

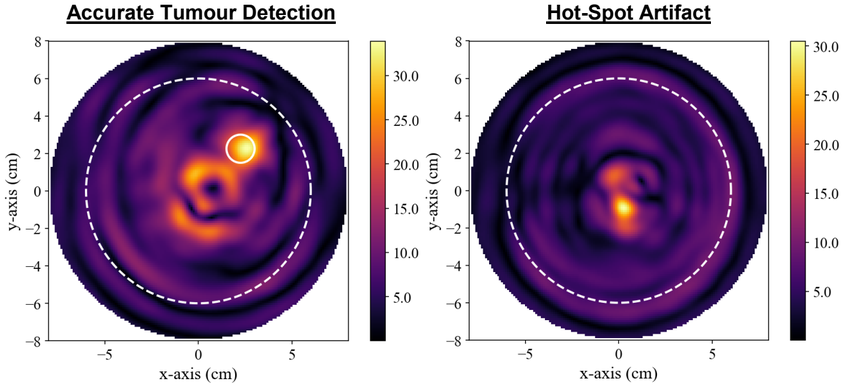
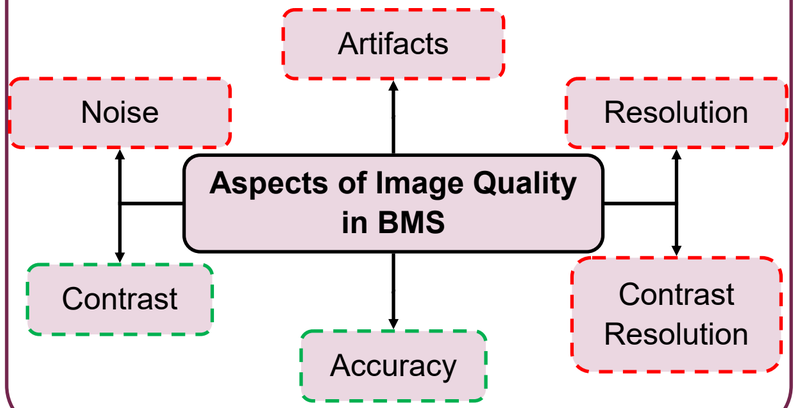


Fig. 1: Coronal reconstructions of breast phantoms from the open-access dataset in [2]. Dashed white lines indicate approximate breast boundary, solid white circle indicates tumour location.

- This **focus on image contrast** has **shaped the development** of several image reconstruction algorithms that **enhance contrast at the cost of image accuracy** [1]

Image Quality Analysis



Recommendations for Future Work in BMI

1. Image quality metrics describing **all traditional aspects of image quality** should be developed; special attention should be given to image **artifacts.**
2. **Phantom-based** studies are needed to demonstrate diagnostic potential before additional clinical trials are performed
3. More thorough **comparisons between healthy and tumour-containing phantoms** are needed

References

1. T. Reimer and S. Pistorius, “Review and analysis of tumour detection and image quality analysis in experimental breast microwave sensing,” *Sensors*, vol. 23, no. 11, pp. 1-29, 2023.
2. T. Reimer, J. Krenkevich and S. Pistorius, “An open-access experimental dataset for breast microwave imaging,” in *2020 Eur. Conf. Antennas Propag. (EuCAP)*, Copenhagen, Denmark, 2020, pp. 1-5.