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A Novel Integrated Microwave-Ultrasound Breast Imaging System

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Microwave and ultrasound imaging (MWI, USI) are two modalities being investigated for use in biomedical applications such as breast cancer detection. Both modalities offer the benefit of using non-ionizing radiation, unlike traditional x-ray mammography. In MWI, the object of interest (OI) is surrounded by antennas that, in turn, illuminate the OI with electromagnetic energy in the microwave frequency range. Field data is collected at all antenna positions. For USI, the OI is surrounded by piezoelectric transducers that successively transmit ultrasonic waves into the OI. Field data is collected by all other transducers in the system. In both cases, the received data is passed to imaging algorithms that reconstruct material properties of the OI. In MWI, the material property of interest is the complex-valued permittivity (related to the dielectric constant and loss). In USI, the speed of sound and attenuation are reconstructed. In addition to the quantitative imaging of these properties, qualitative imaging techniques may also used to obtain structural information about the OI. Information obtained from modalities based on different physics may be utilized not only to fuse information gained from each modality into a single image, such as in [1], but also to incorporate information from one modality into the other during the reconstruction process, *e.g.* [2].

In this work, we report on the development of an integrated MW-US breast imaging system capable of collecting both US and MW imaging data without repositioning the breast. In the integrated system, USI extracts anatomical tissue information, demarcating the skin, fat, and fibroglandular regions. This is used as prior information in the MWI reconstruction of the complex-valued permittivity as demonstrated in [2, 3]. The integrated system is built upon the same air-based, flat-faceted, quasi-resonant MWI chamber described in [4], operating in the 1.0-1.8 GHz range. An ultrasound fixture has transducers arranged in several co-axial rings, forming a cylindrical array around the OI. The system allows collection of US and MW data without repositioning the breast, solving the problem of co-registration.

To test the system, we have created gelatin-based tissue-mimicking phantoms for USI based on Medina-Valdés *et al.'s* recipe [5], modified to also exhibit dielectric properties similar to those of breast tissues in the frequency band of interest. Preliminary results obtained with the integrated system will be presented at the conference. The configuration of the transducers in the US fixture, their number and positioning around the breast, will be studied in terms of the achievable accuracy and resolution of the resulting anatomical information. Algorithms to extract US prior information, which result in different forms of prior information, as well as various techniques of incorporating that prior information into our MWI algorithms, will be investigated.

References

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