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RECONSTRUCTION OF EXTREMELY DENSE BREAST COMPOSITION UTILIZING INVERSE SCATTERING TECHNIQUE INTEGRATED WITH FREQUENCY-HOPPING APPROACH

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ABSTRACT

The Forward-Backward Time-Stepping (FBTS) inverse scattering technique is utilized for breast composition reconstruction of an extremely dense breast model at different center frequencies. A numerical extremely dense breast phantom is used and resized to suit the Finite-Difference Time-Domain (FDTD) lattice environment utilizing two-dimensional (2-D) FBTS technique. The average value of fibro glandular region for reconstruction with Frequency-hopping approach applied is much closer to average value of the actual image compared to the reconstruction without Frequency-approach applied. Hence, the composition of the extremely dense breast model can be reconstructed with Frequency-hopping approach is applied and the details of the reconstruction is also enhanced.

Keywords: breast imaging, frequency-hopping, inverse scattering.

INTRODUCTION

In developed country, breast cancer is a top ranked cancer although it is rare in men (DeSantis *et al.* 2014). Based on the findings, breast cancer ranks first among the women especially women aged between 20 to 59 years old. According to the breast cancer mortality trend, there will be 40,430 expected deaths caused by breast cancer which includes 40,000 women and 430 men as reported in Siegel *et al.* (2014). Therefore, annually breast screening is essential for early breast cancer detection and proper treatment to reduce the breast cancer mortality.

Clinical breast examination and mammography are the common breast screening methods for women at average risk. X-ray mammography is the standard screening method for breast tumour detection (Champaign and Cederbom, 2000). Based on the studies on mammography, radiologists recommended depicting the severity by using the American College of Radiology's (ACR) Breast Imaging Reporting and Data System (BI-RADS). BI-RADS becomes the standard in the mammographic density assessment (Liberman, 2002).

According to the studies in Tabar and Dean (2010), it indicated that the breast density is one of the risk factors causing missed cancers (false-positive and false-negative) in mammographic interpretations especially on dense breasts. The sensitivity of the X-ray screening mammography is lower for women with heterogeneously dense or very dense breasts according to Joy *et al.* (2005). In Kolb *et al.* (2002) stated that more than 11,000 women without clinical symptoms of breast cancer, the sensitivity of mammography was only 48% for the extremely dense breasts compared to the entire sample of women with 78% sensitivity.

The mentioned limitations have demonstrated a weighty challenge to the accuracy of early detection of breast cancer. It is also contributing to the alternative detection techniques by many researchers (Li and Hagness, 2001), (Hassan and El-Shenawee, 2011). The nonionizing microwave breast imaging is rationale due to the significant contrast in the dielectric properties of normal breast tissue and malignant tumours (Chaudhary *et al.* 1984). There are various types of active microwave approaches utilizing frequency-domain inverse scattering (Qianqian *et al.* 2004) and ultra-wideband (UWB) radar-based techniques (Li *et al.* 2004) for breast imaging. These approaches demonstrated that the tumours can be detected both in phantom experiments and numerical studies (Ping *et al.* 2009). Furthermore, time-domain scattering data contains more information as compared to frequency-domain scattering data. Hence, electromagnetic imaging in time-domain has the potential to reconstruct electrical profiles more accurately.

In this paper, there will be discussing the Forward-Backward Time-Stepping (FBTS) technique utilizing broadband microwave signals in order to overcome the inverse scattering problem in time domain. This technique was reported by Takenaka *et al.* (2000) for a simple one-dimensional case and has been extended for reconstruction of a two-dimensional (2-D) heterogeneous breast model (Johnson *et al.* 2008), (Ping *et al.* 2008). In this paper, research work is focused on 2-D FBTS utilizing the numerical extremely dense breast model in free space for breast composition reconstruction. FBTS technique possesses the ability to reconstruct the composition of the extremely dense breast.