Improvement of Artificial Neural Network Detection of Breast Cancer using Broadband Dual Polarized Antenna

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Abstract:

This work represents a numerical investigation into the improvement of Artificial Neural Network detection of breast cancer using a planar broadband antenna and a three-region breast model. Modified Fourpoint antennas are used, which are capable of producing various wave polarizations. The effect of wave polarization on statistical detection will be investigated in this paper.

Introduction

As the sophistication of Artificial Neural Networks (ANNs) and other learning systems are enhanced, their applications become increasingly diverse. The ability to provide real-time results coupled with almost limitless configurability makes ANNs a good candidate for the statistical detection of breast cancer. In previous work, the use of an Artificial Neural Network as a preprocessor to microwave imaging was demonstrated [1]. The previous work used a plane wave excitation with a simplified two-region model of the breast. In this work a more realistic breast model is used in conjunction with a broadband dual polarized antenna. Recent work has been done showing the benefits of using cross polarized antennas [2].

Excitation Source

The Fourpoint antenna is a broadband planar antenna which is capable of providing dual linear and circular polarization [3]. For this application the original design is modified to shift the frequency band and reduce the overall size of the antenna. Figure 1 provides the calculated S11 of the antenna in air and the immersion medium (oil). The effect of the orientation of a non-spherical tumor is tested by rotating the

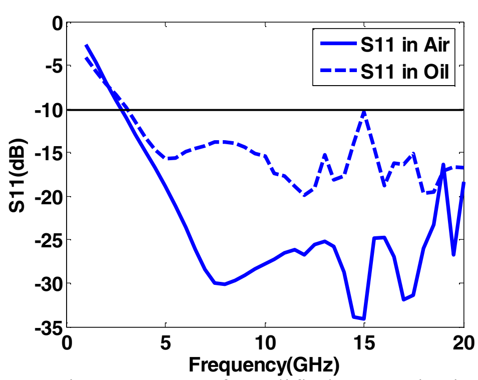

Figure 1: S11 of Modified Fourpoint in Air and Oil

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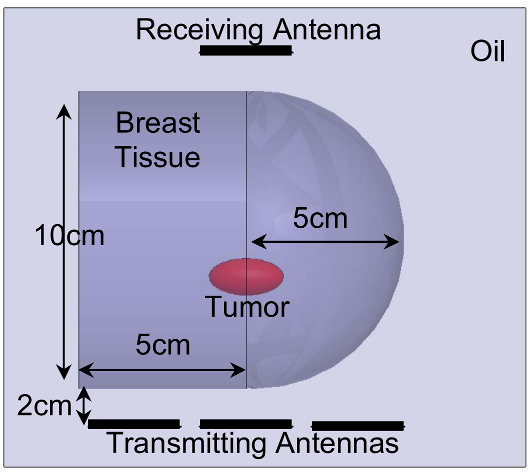
tumor within the breast model. The orientations used in this work are; parallel to the direction of wave polarization, perpendicular to the direction of wave polarization, and halfway between the two.

The Breast Model

The dielectric properties of the human breast have been studied and the values are presented in the literature [4]. Additionally, studies on the effect of using various immersion liquids have been documented, with oil (ε_r = 3) providing the best results [5]. In this work oil is used as the immersion liquid with the breast tissue and tumor properties used from the ranges provided in the literature (see figure 2). The dielectric properties are chosen randomly in the specified ranges. The tumor has a radius of 10mm on the primary axis and 5mm on the secondary axis. The effect of the skin is ignored in this work, although studies have been done on the effect of skin and the error introduced by ignoring it [6].



Oil: $\hat{\varepsilon}_{ro} = 3$

Breast: $\hat{\varepsilon}_{r_B} = (9 - j) \rightarrow (25 - j6)$

Tumor: $\hat{\varepsilon}_{r_T} = (40 - j10) \rightarrow (60 - j30)$

Figure 2: Breast model with three regions

Method

For simplicity, the initial setup and testing of the breast model is completed using an array of patch antennas. Patch antennas operating at a frequency of 10GHz with a bandwidth of 6.8% are used. At higher frequencies the scattering from the tumor is more recognizable, although the attenuation within the breast tissue is a factor. To increase the magnitude of the scattered fields at the receiver location, an array of antennas is designed to focus the beam in the direction of the tumor. It is important, however, that the power incident on the surface of the breast does not exceed IEEE safety standards of 10mw/cm^2 for controlled environments [7].

A commercially available software package, Ansoft High Frequency Structure Simulator (HFSS), was used to calculate the scattered fields at the receiver location. The simulations were repeated one hundred times with no tumor present and one hundred times with a tumor present. The data was then broken into data sets containing fifty cases without a tumor and fifty cases with a tumor. One data set is used to train the ANN, while the remaining data set is used to test the predictive ability of the network. Synthetic noise was added to each dataset based on a Gaussian distribution and varying standard deviations, σ_n (σ_n = .001,.01,.1,.2, and .3). Multiple neural networks were configured using this synthetic data and they were tested versus each testing set. The same procedure will be followed when the patch antennas are replaced with Fourpoint antennas for each of the three ellipsoidal tumor orientations.

Results

To receive adequate signal at the receiver location without exceeding the specified safety limits, an array of three patch antennas was designed to focus the main beam in the direction of the tumor. The distance between the breast and the antenna array is 2cm with a total feeding power of 300mW. After the data was collected at the receiver location using the methods described above, ANN analysis is performed.

A modified Youden's Index is used to determine the optimal cutoff for the network as used in previous work [1]. Using this optimized cutoff value the number of false positives, false negatives, and correctly identified results were tabulated and plotted.

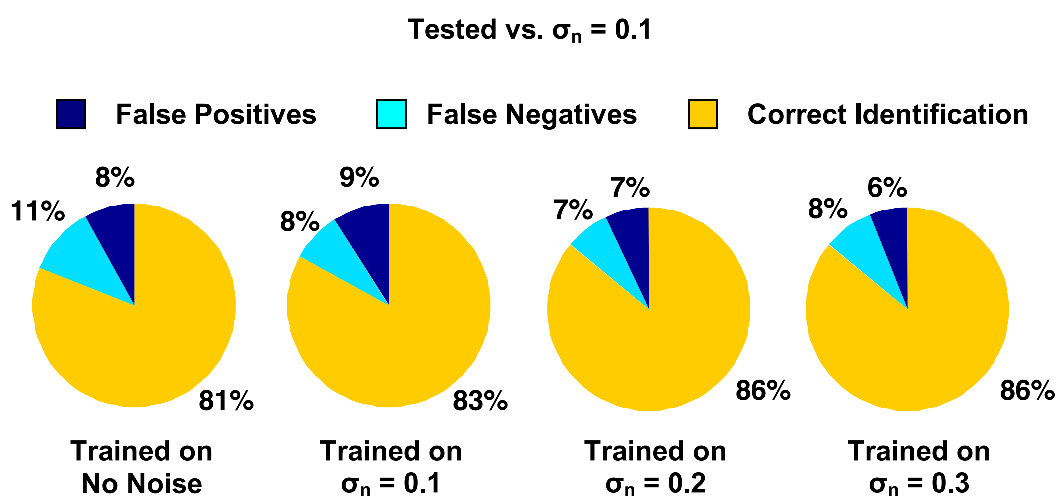


Figure 3: Results for various training networks vs. data with σ_n = 0.1

Conclusion

The results achieved using the patch antenna array with the three region model is similar to those found using the two-region model and plane wave excitation [1]. The use of patch antennas is not optimal and is not the end goal, however, the inherent simplicity of patch antennas allows for their use as a test for the model and the diagnostic network. By exchanging the patch antenna array for an array of wideband dual polarized antennas, the effect of wave polarization on ANN detection of breast cancer will be determined. It is expected that the wave polarization and tumor orientation will have an effect on the accuracy of the ANN. If this is the case, then utilizing an antenna with dual polarizations will allow for more accurate detection of a breast tumor. The results from this case will be presented and discussed in the conference.

Acknowledgements

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