BREAST CANCER TUMOUR DETECTION USING MICROWAVE RADAR TECHNIQUES

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Abstract: A breast cancer detection technique using multi-static radar is proposed herein. Images of a breast tumour are produced using this technique, with backscatter data. A wideband antenna design suitable for a breast cancer detection system is also described. Practical measurements are performed using a network analyser and a pair of antennas that are used to simulate an array. These initial images demonstrate the successful detection of a tumour phantom immersed in a liquid phantom with similar dielectric properties as the breast tissues.

INTRODUCTION

Each year, there are nearly 41,000 new breast cancer cases in the UK [1] and it is the most common cancer for women there. Early detection of breast cancer tumours is very important for successful cancer treatments. X-ray mammography is currently the most effective technique [2], however it suffers from a relatively high missed- and false-detection rates and involves uncomfortable compression of the breast. X-rays are also ionising and therefore not generally suited to frequent screening.

Breast cancer tumour detection using Microwave Radar techniques is a non-ionising, potentially low-cost and potentially more certain alternative. Microwave detection of tumours is based on the significant contrast between in the dielectric properties of normal and malignant breast tissues [3]. The work presented here employs a post reception synthetically focussed detection method developed for a Ground Penetrating Radar (GPR) system[4]. In this technique all elements of an antenna array transmit a broadband signal in turn, the elements sharing a field of view with the current transmit element then record the received signal. By predicting the path delay between transmit and receive antennas via any desired point in the breast, it is then possible to extract and time-align all the signals from that point. Repeated for all points in the breast, this yields an image in which the distinct dielectric properties of malignant tissue are potentially visible. Unlike the non-contact GPR system, the breast cancer system employs a matching dielectric material between the antenna array and the breast to minimise the clutter arising from the air-breast interface.

In this paper an antenna design for the radar system and measurements performed on breast dielectric phantom are presented. These initial investigations were conducted to analyse the feasibility of using Microwaves for tumour detection.

ANTENNA DESIGN

The antenna design for the breast cancer detection system was carried out using FDTD simulations. This system requires a wide band antenna array capable of producing high-resolution images. The lateral and vertical resolutions of a post reception synthetically focussed method depends on the frequency of operation and the beamwidth of the antennas. A higher operating frequency and a wide antenna beamwidth are desirable, however due to the high attenuation losses of breast tissues at higher frequencies the operating frequency has to be limited below 10 GHz.

Figure 1 shows the stacked patch antenna designed to operate at 6.5 GHz. This antenna was designed to radiate into a medium with a dielectric permitivity of 9.5. The patch antennas were printed on a $\varepsilon_r = 2.2$ dielectric substrate which was separated from the antenna ground plane using a $\varepsilon_r = 10.2$ substrate. The stacked patch was fed through a slot in the ground plane employing a microstrip line printed on the other side of the antenna ground plane.

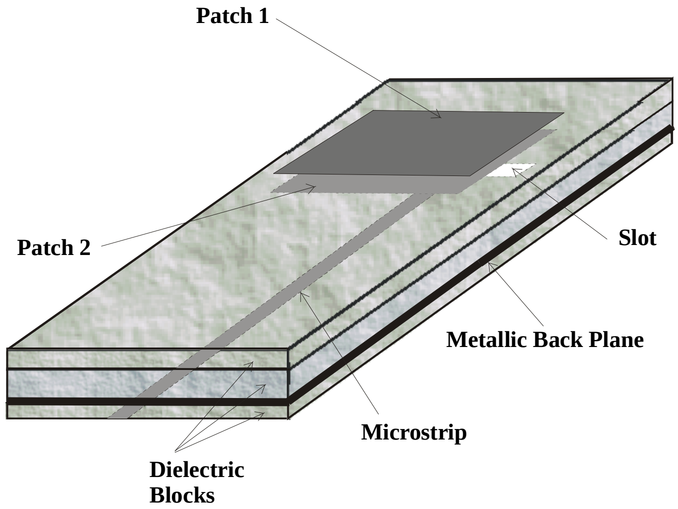

Figure 1 Stacked Patch Antenna

This antenna had a -10 dB feed-antenna match from 4.5GHz to 9.5GHz broadly satisfying the system requirements. The antenna radiation patterns in the near fields were calculated using FDTD techniques and satisfactory patterns were observed in the matched frequency range. The antenna patterns started to slightly deteriorate at the upper frequency limit.

MEASUREMENTS

Practical measurements were carried out using a pair of stacked patch antennas. The antennas were physically scanned over the dielectric phantom that also contained a tumour phantom. The liquid dielectric phantom for the breast tissue was developed using an emulsion of oil and water and the tumour phantom with a gelling agent (TX151) and water. Frequency domain data collection was performed using a Network analyser and the S_{21} parameter was recorded at different antenna locations. The recorded data was then converted to time domain employing inverse Fourier transform techniques. A suitable time domain pulse that can be transmitted employing the antenna bandwidth without much distortion was assumed in this transformation. The synthetic focussing and time alignment process was performed in the time domain to produce three-dimensional images as shown in equation 1.

$$V = \int_0^{\tau} \left(\sum_{i=1}^{N} w_i U_i (t - T_i) \right)^2 dt \qquad (1)$$

where,

$U_i(t)$	Signal received from path *i*,
N	Number of paths associated with the resolution cell,
w_i	Weighting factor associated with the attenuation, spreading losses along path *i*,
T_i	Path delay associated with the trip to and back from the resolution cell.

Figure 2 shows a horizontal and vertical slices at the target location with the tumour at the correct location.

CONCLUSION

A breast cancer detection system using microwave radar techniques has been described with a suitable antenna design. The feasibility of such system was practically analysed and the results obtained with preliminary investigations indicate the presence of the tumour at its correct location. Future work includes the incorporation of the skin and suitable techniques to handle clutter arising from these discontinuities.

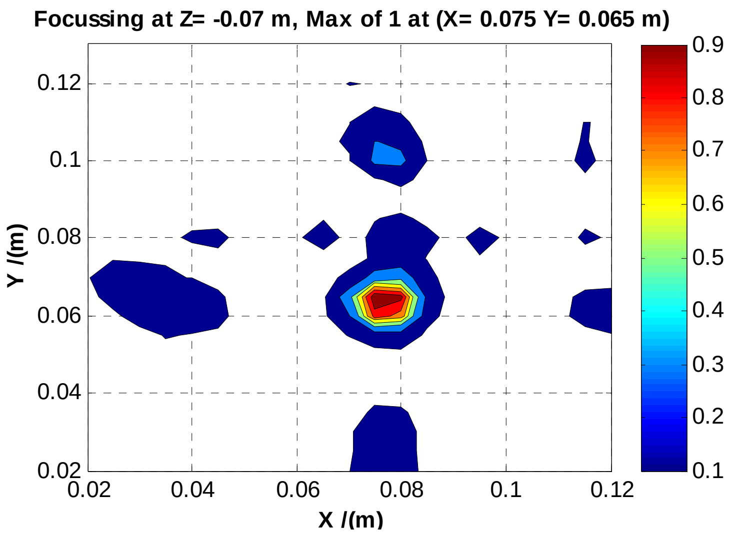

Figure 2 Horizontal Slice through target

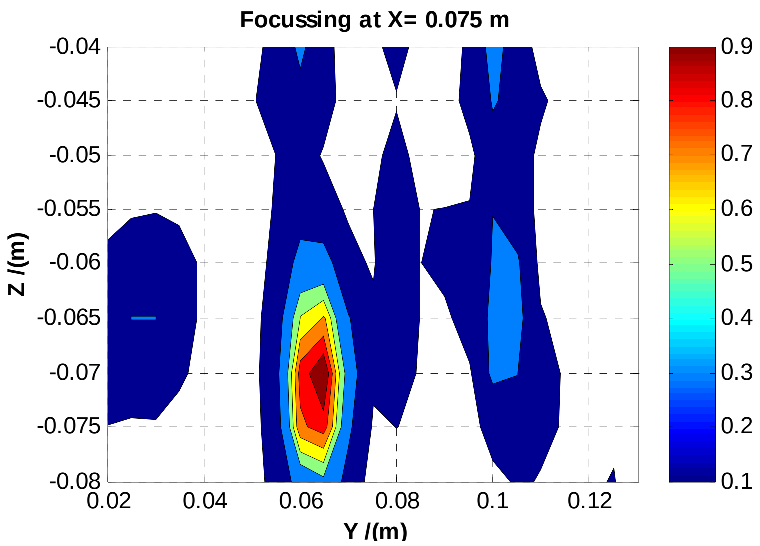

Figure 3 Vertical Slice through target

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