A Comparative study between two microstrip antennas-Application in microwave imaging

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Abstract **–** In the field of microwave imaging, the homogenous objects reconstruction from electromagnetic scattered fields have been shown to be of high importance, because of their applications in many domain such as biology, biomedical diagnostics, civil engineering and other sciences. In this paper, we propose a comparative study of the database results for two different microstrip antennas (bowtie and rectangular microstrip) for detection and localization of the breast cancer. The proposed technique is based on using the artificial neural network approach; a tumor having a spherical shape with 3 mm radius has been placed at different locations in breast model developed using CST software. The obtained results show a proportional relationship between bandwidth of antenna and the frequency of the transmitted pulse and the merits of the proposed approach in terms of detection and localization. However, the results given by rectangular microstrip antenna are very far from the real position of the tumor.

Keywords–Antennas; microwave imaging; neural networks.

I. INTRODUCTION

Breast cancer affects many women and early detection aids in fast and effective treatment. X-ray mammography is currently the most effective imaging method for detecting clinically occult breast cancer. However, despite significant progress in improving mammographic techniques for detecting and characterizing breast lesions, mammography reported high false-negative rates [1] and high false-positive rates [2]. These difficulties are attributed to the intrinsic contrast between normal and malignant tissues at X-ray frequencies. For soft tissues like human breast, X-ray cannot image the breast anomalies at an early stage, as there is no significant variation in density between normal and malignant breast tissues [3].

Microwave imaging is a new technology which has potential applications in the field of diagnostic medicine [4, 5]. Actually, there are different antennas that are used as transmitters and receivers for medical applications, In this paper we propose a comparative study of the results database for two different antennas for detection and localization of the breast cancer.

In the present study, a spherical tumor of radius 0.3 cm has been created and placed anywhere in a breast model developed in EM simulator. In the initial stage, we have used two Bow-tie antennas for the transmission and reception of signals at 4 GHz, in the second stage we have used two rectangular antennas. The proposed technique used for detection and localization is based on using the artificial neural network approach. This latter is very well suitable for microwave imaging breat cancer detection.

This paper is organized as follows. The next section presents the breast model and data collection technique, followed by results and discussions, and finally the conclusion of the paper

II. BREST MODEL FOR DATA COLLECTION

In this paper, we have developed the breast model in EM simulator for generation the database, where the geometrical property of this model as presented in Figure 1 and Table 1.

Table I. Model parts sizes

Model part	Size (cm)
Breast diameter	10
Breast height	6
Skin thickness	0.2
Chest thickness	2

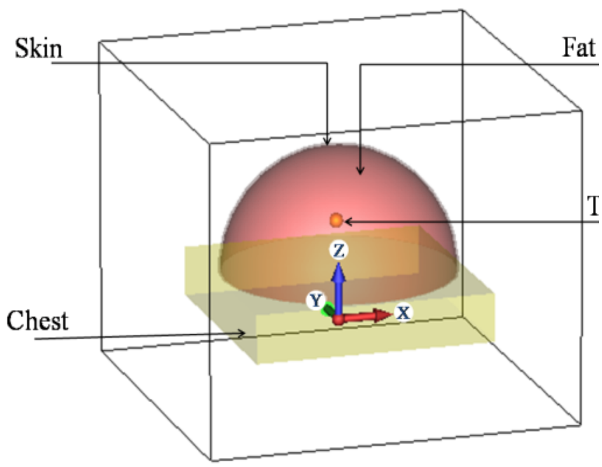

Fig.1. View of Brest model in EM simulator

In the literature [2, 6, 7, 8] the tumor radius size ranges from 0.2 cm to about 1.5 cm or more, In this case, we took a tumor with a radius of 0.3 cm is close to its minimum size.

The dielectric properties that have been used are shown in Table 2 [9, 10] where σ is the tissue conductivity in (Siemens/meter) and ε_r is the relative permittivity.

Table II. Dielectric Properties of the brest model

	Conductivity σ (S/M)	Permittivityε_r
Skin	1.49	37.9
Fat	0.14	5.14
Chest	1.85	53.5
Tumor	1.20	50

As mentioned above, divers types of antennas have been used in microwave imaging systems, we chose two types antennas (Bow-tie antennas, rectangular antennas) to behold the influence of the bandwidth of the antenna on the detection and localization of the tumor.

A. Bow-tie antennas

This type of antenna is very used in our field of research. In this work we used a bow-tie antennas developed by N. Seladji-Hassaine and all [11] the geometrical property is that have been used are shown in figure 2 and Table 3

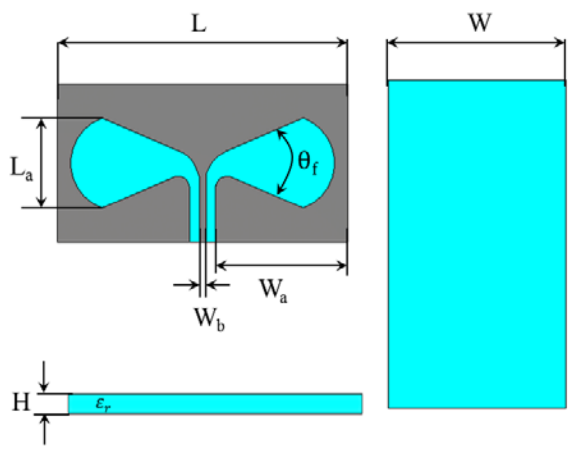

Fig. 2. View of bow-tie antenna

Parameter	Size
H	1,66 mm
θ_f	73°
L	44 mm
W	24 mm
W_a	20 mm
W_b	1 mm
L_a	13 mm
ε_r	3,3

Table III. Parameters of bow-tie antenna

The figure 3 represents the return loss as a function of the frequency of the bowtie antenna used where it is clearly mentioned that the antenna is ultra wideband type.

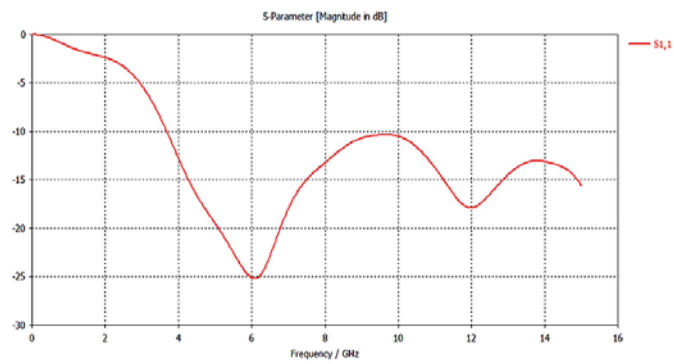

Fig. 3. Return loss of bow-tie antenna

In order to send Gaussian impulses, two bowtie antennas (transmit / receive) separated by the breast model were used (figure 4).

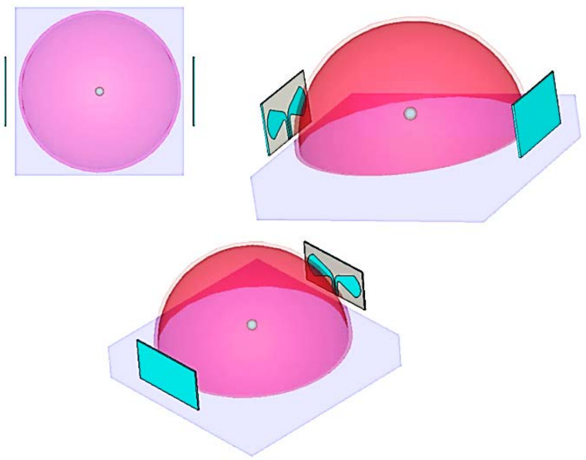

Fig.4. Position of the antennas in the breast model

B. Rectangular microstrip antennas

Rectangular microstrip antennas are interrogated in UWB applications, particularly in medical imaging. This is due to their low profile, compactness and ease of integration. That said, the micro ribbon antenna has some disadvantages: a low gain and a narrow bandwidth. A miniature UWB micro ribbon antenna has been developed by [12] that meets the requirements of microwave imaging.

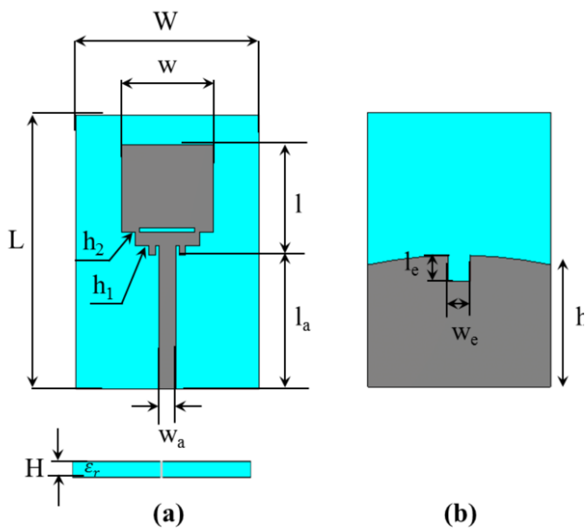

Fig.5. Rectangular microstrip antennas

The geometry of the antenna used is shown in figure (5) and table (4). The antenna is a rectangular patch that has undergone a number of modifications to overcome the limitation of its bandwidth, narrow originally.

Table IV. Parameters of rectangular microstrip antennas

Parameter	Size
l	12 mm
θ_f	73°
w	10 mm
H	0,794 mm
L	30 mm
w_a	1,8 mm
h_1	1 mm
h_2	1,5 mm
ε_r	3,3
h	13,2
l_e	3 mm
w_e	2,4 mm

Figure (6) illustrates the return loss of the antenna as a function of frequency. The bandwidth measured at -10dB ranges from 3,55 Ghz to 11,17 Ghz, a width of 7.62 Ghz.

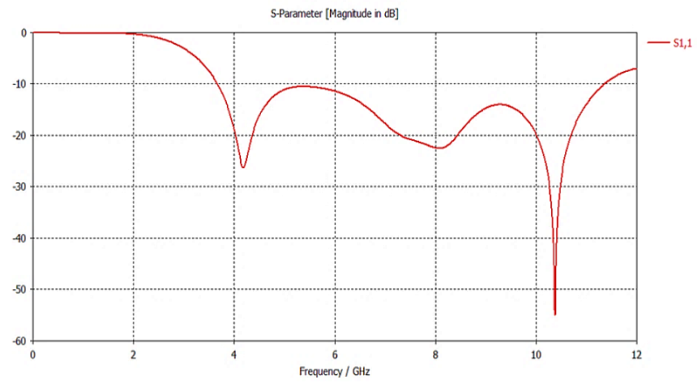

Fig.6. Return loss of rectangular microstrip antennas

In order to generate a database of tumor positions, two rectangular microstrip antennas are used. The first antenna is placed in front of the breast model with the intention of sending a Gaussian pulse of 4 Ghz, the second antenna is placed opposite the first with the objective of receiving the signal in the opposite point (figure 7).

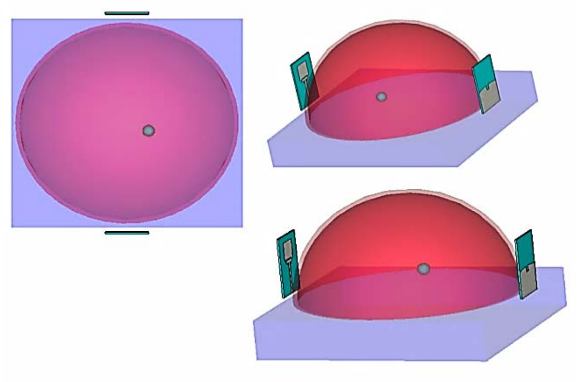

Fig.7. Position of the antennas in the breast model

C. Data collection

The two antennas presented previously were used for the transmission of a Gaussian pulse whose central frequency is 4GHz and for the recovery of the diffused signal.

The database contains a set of data (input / output) obtained by simulation using the software "CST" (Figure 4) and (Figure 7). For this, we proceeded as follows:

1) Place a pair of transmitter - receiver at opposite sides of the breast model;
2) Place a tumor at any location in the model;
3) Transmit a Gaussian pulse of a plane wave in the direction of the x-axis;
4) Receive the signal on the opposite side;
5) Change tumor location and repeat (3–4).and repeating the steps (3-4).

This process of data generation was performed for 45 different locations by moving the tumor along the axis 'y' for two types of antennas bow-tie antenna and rectangular microstrip antennas.

Also, breast model without tumor tissue was used 5 times to obtain signals propagated through the breast tissue. As a result, two groups of signals received were formed for each type of antenna as follows

Group (1): a set of 40 signals (37 with tumor and 3 without tumors) were used for NN learning.

Group (2): a set of 10 signals (8 with tumor and 2 without tumors) were used for the test phase of the NN.

D. Preprocessing data

The signals received by the receiver contain a number of samples that can be from 4500 to 7200 samples (Figure 8). To reduce this number and to fix a sampling step of the signal we make a Cubic Hermite Interpolating Polynomial to generate a polynomial P (xi) while keeping the same pace of the signal. The number of samples obtained after interpolation with a step of 0.01 in the segment (1.8 ns and 3.62 ns) is 183

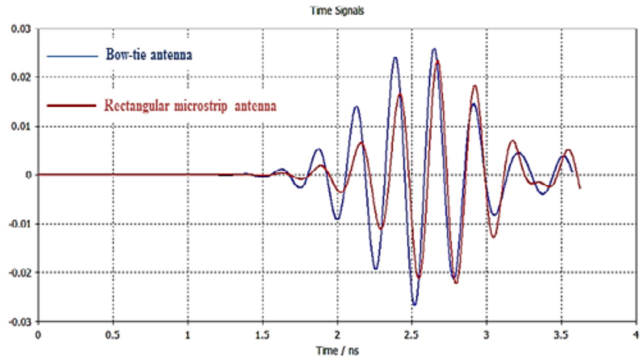

Fig.8. Received signal

III. CONSTRUCTION OF NEURAL NETWORK

The construction of the neural network is done through an iterative process on samples of a previously built database. There are no theoretical results, or even empirical rules that allow dimensioning a neural network based problem to resolve. The design of a multilayer network is experimentally, the difficulty usually arises when choosing the number of hidden layer, and the number of the nodes in each hidden layer [13, 14]. After several tests, a multilayer network was selected for the two databases of the two antennas with the topology presented in table 5.

Table V. ANN Parameters

Parameters of ANN	Values
Number of nodes in input layer	183
Number of nodes in hidden layer 1	40
Number of nodes in hidden layer 2	15
Number of nodes in output layer	1
Activation function	Sigmoïde
Training function	Traingdm
Learning rate	0,012
Number of iterations	0,9

When the network architecture has been agreed, the learning phase is used to calculate the synaptic points (Wi) for each node final [13]. The used transfer function is “tansig” which has output in the range [−1, +1]. The training function is “traingdm” which is gradient descent with momentum back-propagation. The parameters of the topology and training are summarized in Table (5)

IV. RESULTS

When the learning phase is finished, we tested the performance of ANN using group 2. Note that the two types of antennas have given a good detection of the tumor. While for the localization, the bowtie antenna gave results of the position of the tumor very close to the real position of the latter, but the results given by the rectangular patch ribbon micro antenna are very far from the actual position of the tumor (Table 6). It can be seen that the detection rate is estimated a 100%. The -1 mean that there is no tumor in the breast.

Table VI. Actual Tumor Locations and The Ann Output

	Bow-tie antenna	Rectangular microstrip antenna
Actual tumor location (en cm)	ANN output (cm)	ANN output (cm)
0,28	0,2592	0,4591
0,4	0,4003	0,4861
-1	-1	-1
0,52	0,5235	0,3591
0,6	0,5675	0,4467
0,68	0,674	0,1110
0,78	0,7506	0,2622
0,34	0,3277	0,5386
0,46	0,4394	0,4436
-1	-0,9980	-1

V. CONCLUSION

In this paper, neuron network with two hidden layers and gradient descent with momentum back propagation was used to identify the existence and location of the tumor tissue in a breast model. According to the table 6, we can see that two types of antennas gave good tumor detection. But for localization of tumor, the results given by bow-tie antenna are very close to the real position of tumor, but the results given by rectangular microstrip antenna are very far from the real position of the tumor. In conclusion, we can say that a bandwidth of 7,62 GHz of rectangular microstrip antenna is insufficient to send a pulse of 4 GHz it is for this reason that the pulse received from the rectangular antenna is distorted figure 8. In future work we will study: detection and localization the tumors in two or three directions.

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