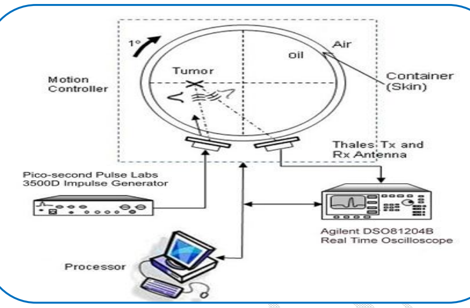
REVIEW OF RESEARCH
IMPACT FACTOR : 5.7631(UIF) UGC APPROVED JOURNAL NO. 48514 ISSN: 2249-894X

VOLUME - 8 | ISSUE - 7 | APRIL - 2019

EARLY STAGE DETECTION OF BREAST TUMOUR BY MICROWAVE TECHNOLOGY

Dr. Rashmi Rekha
Faculty (G) of science (Physics), C. M. Sc. College, Darbhanga, L. N. Mithila University, Darbhanga, Bihar, India.



ABSTRACT:

The detection of formation of breast tumour in the early stage can be made available by application of microwave technology. The technique presented is easy to understand and cost effective, having no any side effect. The dielectric property of alienated part is changed due to hydration. The back scattering of ultra wide band wave increases appreciably which makes possible early stage breast tumour detection. Breast phantoms and tumours may be created by varying the dielectric permittivity of materials used in software. Findings are presented using the simulated results obtained.

KEYWORDS: *Ultra wide band (UWB) microwaves, Breast tissues, Simulation, Ultra wide band (UWB) antenna*

1. INTRODUCTION:

Generally the breast cancer may be originated in the breast tissues. In most of the cases this disease can be visualised easily. There are lot of signs which indicate the growth of breast tissues. It includes a lump in the breast, a change in breast shape, dimpling of the skin and fluid coming out from the nipple. Sometimes there is constant pain in part of the breast or armpit. Sometimes swelling beneath the armpit or around the collarbone or, a red scaly patch of skin has been reported as the signs of breast cancers. Generally, a lump in the breast is the major sign of the disease. It can be discovered at the early stage of the disease in the patient.

But only a lump cannot be considered final and the patient can be diagnosed to be a cancer patient because only 20% lumps in breast are cancerous.[11] A lump is said to be formed when the portion of breast feels different from the other part of breast tissue. The earliest breast cancers are detected by a mammogram. Breast diseases such as mastitis and fibro adenoma of the breast are more common causes of breast disorder symptoms.[4] Symptoms of breast cancer include breast inflammation and it may include itching, pain, swelling, nipple inversion, warmth and redness throughout the breast, as well as an orange-peel texture to the skin. Inflammatory breast cancer is a particular type of breast cancer which poses a substantial diagnostic challenge because in this case no lumps are formed.[4-19] The breast cancer presents as metastatic disease. The symptoms caused by metastatic breast cancer will depend on the location of metastatic.

2. DIELECTRIC PROPERTY EVALUATION OF BREAST TUMOR:

Schlepps and Foster (1980) reported the dependence of tissue dielectric properties, as a function of frequency on water content. This equation, evaluated for each voxel, delivers the 3D dielectric human body model.[7] The assumption behind the method of Schlepps and Foster for the calculation of dielectric constants from the water content of a tissue is that, in the microwave range, cell membranes have very low impedance and tissues can be compared to suspensions of proteins in water. The Eq. [13] shows these relationships:

$$\mathcal{E} = \mathcal{E}_w \left\{ \frac{1-P}{1+(K-1)P} \right\}\left\{ 1+ \frac{KP}{\mathcal{E}w(1-P)}\mathcal{E}_p \right\} \text{------} [1]$$

Where $\mathcal{E}_w$ is the permittivity of water, it is given at a specific microwave frequency; P is the volume fraction of suspended solid, $\mathcal{E}_P$ is the permittivity of the protein molecule; K is a factor which depends on geometry and $\mathcal{E}_P$. Mazzurana and colleagues decided to proceed with the formulation of an empirical transfer function which relates directly the image signal with the relative permittivity and conductivity at a known frequency.

3. WATER CONTENT EVALUATION:

For this evaluation, the equation proposed by Fatouros and Marmarou (1999) has been used as given in equation (2). Here A and B are parameters experimentally found out, and fw is the water fraction (the unknown).

$$\frac{1}{fw} = A + \frac{B}{T1} \text{------} [2]$$

A and B are factors that depend on magnetic field strength. T1 is the longitudinal relaxation time constant; it indicates the time required to regain longitudinal magnetization following an RF pulse. Fatouros and Marmarou verified the linearity between 1/T1 and 1/ f both in gelatin solutions of varying water content and in an experimental animal model of brain edema. This equation is available in the literature, (Shah et al., 2011) . In particular, the relative amount of water in an image voxel is evaluated comparing the number of resonant protons in a region of interest of 100% H2o with the number of protons in a voxel. Also, the female breast tissues have been studied, with focus on the breast tumor detection. Ex vivo measurement of fresh human malignant and normal breast tissues has been performed by several groups. Chaudhary et. al. between 3 MHz–3 GHz [17], Surowiec et. al. between 20 kHz–100 MHz [3], Campbell et. al. at 3.2 GHz [2] and Joines et. al. between 50 MHz–900 MHz.[18] The conclusion from those measurements is a significant contrast between malignant tissues and normal breast tissues, approximately 4:1 in permittivity and between 4–8:1 in conductivity along the frequency band of microwaves. The measured values differs significantly between different patients due to both measurement difficulties and the rate of fibroglandular tissues. Moreover, this contrast seems to be slightly overestimated while the dielectric properties of the tissues are changed when they are removed, due to changes in blood flow, water content and the metabolism is interrupted [8]. Using the iterative non-linear inverse scattering algorithms the resolution in the reconstruction is less dependent of the wavelength compared to diffraction tomography, much more important is the SNR and model errors.[12] Physically there is two major phenomenon concerning the response level of the received microwave. First, if there is a high contrast in complex permittivity between the background medium and the object itself a major diffraction phenomenon will occur in the surface of the object. Secondly, if high losses in the object In this case it is clear that the dynamical response from an inhomogeneity inside the object will be very low, especially in relatively large objects.

$$SNR = 10 \log \left(\frac{Emean\,(x,y)^2}{\sigma^2} \right) \text{------} [3]$$

This can be described by an simplified example, where only the cross sectional path through the center of the object may be considered, using a plane wave with a perpendicular incidence to the cylindrical surface of the object, according to Figure 1. During transmission measurements a large contrast between the object and the external medium causes large reflections in both interfaces between the object and the external medium, causing a limited part of the wave passing through the object. Also, in the case of a cylindrical object a major diffraction phenomenon will occur in the first interface making the wave going around the object instead of penetrating into it. If an object with a lossy medium is concerned the response will be attenuated through the path into the object. In this case it is clear that a small inhomogeneity inside the object will be hard to detect. We know that high losses is generally concerned in the human body, limiting the penetration depth of microwaves. However, the fatty tissues in a human breast have lower conductivity and increasing the penetration depth in a case of breast tumor detection. Naturally this would improve the result in any imaging algorithm, as long as the contrast to the background medium is kept at a reasonable level. A study of those properties is motivated by the fact that no algorithm can reconstruct an image with high quality from data with any information of the internal structures of the object.

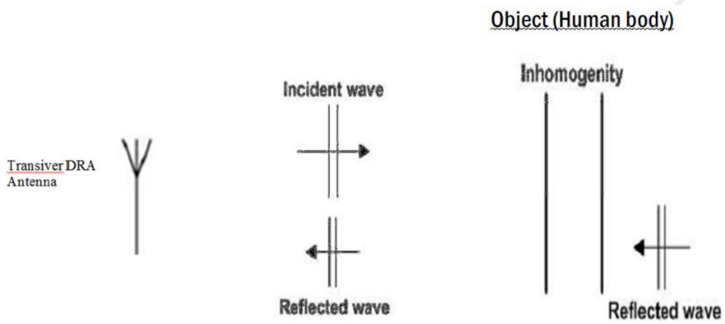


Figure 1: Simplified model of the dynamical response from an inhomogeneity inside an object.

The opening of microwave imaging in biomedical applications were performed by Larsen and Jacobi et.al. in the late 70s, developing a water-immersed antenna for biomedical applications.[21] This was the first time someone was able to penetrate a biological object with microwaves, (due to the wave impedance matching between the water and the human body), to create images of the internal structures.

Since then some kind of water mixtures has been completely dominant as background medium. There is several reasons why water mixtures is a good choice. First, many organs in the human body has permittivity relatively close to water, a reasonable wave impedance matching to the human body is obtained. Secondly, many unwanted secondary effects like interaction between the equipment and the object .The high permittivity will shorten the wavelength improving the resolution of the reconstruction. As we can see that contrast is quite high between fatty breast tissues and water, an interesting point is to see what the obtained responses levels are in a situation of breast tumor detection using water as immersing medium. The results from the feasibility to be used as an example to illustrate the responses of an inhomogeneity in form of a tumor inside a breast.

4. EXPERIMENTAL SETUP:

If the breast tumour can be detected in the early stage of its formation then its prevention can be made easily. Microwave can be used with innovative technology for the early stage detection of breast tumour. A dielectric antenna of suitable material and suitable shape and size can be employed for transmitting the microwave radiation on the malignant part of the breast. The backward scattered wave from the breast phantom can be received by the same microwave dielectric antenna. After proper simulation and processing the image of the hidden breast tumour can be formed. By application of proper analyser the stage of the breast tumour, its size and its location within the breast can be determined. In the figure (2) an arrangement to Detect Breast Cancer using UWB technique has been shown:

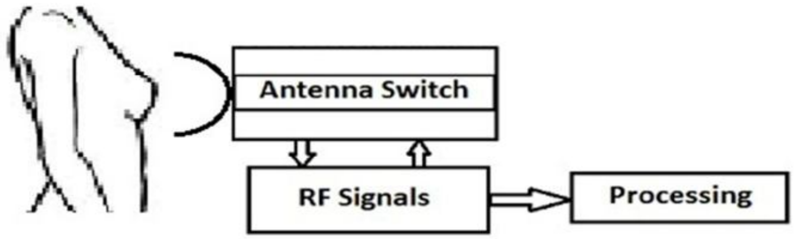


Figure 2: Arrangement to Detect Breast Cancer using UWB

This detection method relies on principle that a malignant tissue has a higher dielectric constant than the normal tissue. It studies the transmission of electrical low level currents due to tissue specific conductivities and permittivity.

5. SIMULATION:

Breast phantoms with tumour in specific part of tissue are modelled in the software. This model is created using materials available in software with varying dielectric permittivity. Upon simulating the model, tumours existence and its characteristics such as shape, size and location can easily be found. Model of a circular tumour having diameter of 1.5 cm is placed in the fat tissue. Figure 3 depicts the simulated result of a breast having a circular tumour in the fat tissue. The location of tumour can be easily detected by relative variation of the intensity of scattered radiation from the defected cell present inside the fat tissue.

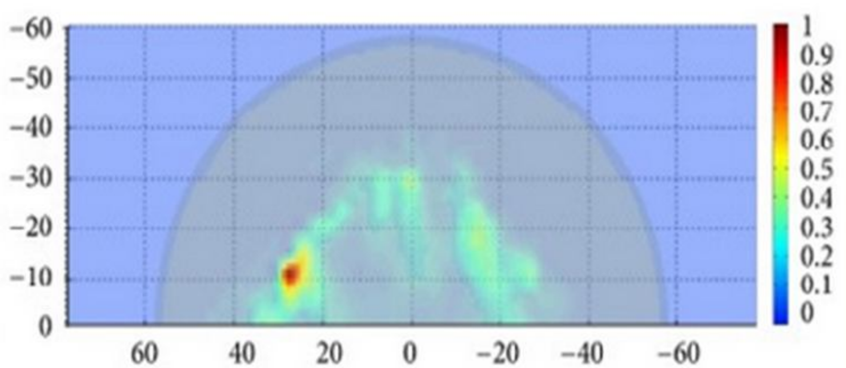


Figure 3: Simulated Result of Affected Breast having Tumour

6. CONCLUSION:

In this paper, application of Ultra Wide Band technique has been introduced to detect the early stage breast cancer. Tissues affected by disease have lump and thus, scattered waves from the affected part of the breast shows sharp variation in the dielectric properties as compared to the normal tissue. This method will be less cost effective for the patients. It will be one of the painless and harmless procedures to detect, this deadly disease in the earliest stage. This will also help the society to become conscious about such disease. New fast and reliable strategies to quantitatively measure the absolute water content can be considered for the future.

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