The Ability of Ultra Wideband Signals in Detection of the Skin Tumor

Mohamed A.A. Eldosoky[1]

[1]Dept of Biomedical Eng, Faculty of Engineering Helwan university
e-mail: hm_eldosoky@hotmail.com   Tel: 002-02-26384473

Abstract

Ultra-wideband radar for diagnosing and detection of the tumors in the human tissue has been developed for many years. this is due to the high resolution and the ability of detection and diagnosing. Skin tumor is one of these tumors that UWB proved is ability to detect it whatever their sizes and positions. this process minimizes the process of biopsy. This paper presents the proposed model for the skin fat and muscle. An inserted tumor will be detected by using UWB.

1. Introduction

Detection of the skin tumor is one of the important aim of the physician in the world. Biopsy is one of the most common and the important method for diagnosing it. The main shortcuts of biopsy are non-invasive method, and long time-consuming, where more than three days are required for determining of a suspected tumor by laboratory [1].
Recently, the development in the ultra wide band (UWB) radar is very vast. This is due the features of the UWB that minimize the fear of using the electromagnetic waves and support it to insert in all medical fields. These features are summarized as: Very low power density, where its input is a very narrow pulse ranges from 100ps to a few nanoseconds. No tissue ionization due to this low power. The bandwidth is more than 20% of the center frequency or more than 500MHz. The average power spectral density should not be over -41.3dBm/MHz. The used frequency range in the medical applications should be between 3.1 to 10.6 GHz [2,3].
Probing the human body is another application of UWB [4], where electromagnetic waves can propagate through the body. A part of them will reflect at the interfaces between materials depending on the difference between their permittivities. These reflections from the different layers enable us to determine if there are strange materials in the direction of the wave, also their positions can be detected.
The applications of UWB in the cancer detection are developed, where the investigators in [5] have proposed a model for liver and its tumor, and they have studied the returned signals at different cases and then they can differentiate between the tumor case and non tumor case. In [6,7], another applications of UWB in detection of early breast cancer are presented. A very narrow pulse with a band of frequencies from 3.1 to 10.6GHz is used. Then the investigators studied the variation in the reflected signal as the tumor is inserted in their models.

In this paper an application of probing the human is presented. This application is the detection of the skin tumor inside a proposed model using FDTD. This model is consisted of three layers, which are the skin, the fat and the muscle. The tumor with different sizes, different positions and different depths is simulated. The scattering parameters between three proposed similar dipoles (as UWB antenna) at different positions will be studied. The effect of this tumor on the reflection and the transmission coefficients will be shown as compared to the non tumor case, where the ability of the reflected parameters alone in detection of the tumor is low and needs many processes to detect the tumor [6,7].

2. Simulation Configuration

a) The proposed UWB antenna

In this model we use three similar dipoles. Each one has a length of 2cm and 3mm in radius. This dipole gives good characteristics as an Ultra wide band antenna with sufficient impedance matching and proper return loss with S_{11} less than 0.3 and voltage standing wave ratio, VSWR <2 with 5.5GHz as a bandwidth.
An array will be formed from three of these dipoles. The distances between them will be 10mm, 35mm and 45 mm. These different distances enable the fields from these dipoles to detect any tumors. This array covers a wide array of the skin and it has the ability to detect any tumor within this area. Consequently, changing the positions of the arrays

for detecting the tumors will be reduced.Beside that this distribution will give a variety in the s-parameters between the dipoles so do impedances between them.

b) Simulation of the human tissues:

In this paper, three different body tissues are simulated in our model, which are the skin, the fat, and the muscle. The skin layer is 2mm as a thickness, the fat layer is 5mm as a thickness. Another layer of muscle tissue with 5mm to 10mm in thickness under the fat tissue will be simulated. The electrical characteristics of these tissues at 6GHz will reconstructed from [8].

3. Results

a) Changing the size of the tumor

The tumor inside this simulation will be simulated as small cylinder with thickness 3mm. The radius of the tumor will be 4mm radius and 2mm. As changing the size of this tumor, the corresponding loads connected to these dipoles affect the reflected signal from each dipole and the transmitted signals from the other dipoles. So using three dipoles will give more parameters about the case that will be studied. Especially, the distances between them are different, so we can deal with each two dipoles as a separated sensor. The variation in S_{11} , S_{22} , S_{33} , S_{12} , S_{13} , and S_{23} as compared to the healthy case are used in detecting the layer compositions and the tumor cases. Guassian wave with frequency from 4.5 to 7GHz is used as input to these dipoles.

The effect of the tumor composite on the above scattering parameters is clear as compared to the no tumor case. Firstly, we will study the effect of the tumor on the reflection coefficients.

1. Reflection Coefficients:

- Figs.1 and 2 show the effect of the tumor on the response of the reflection coefficients. As focusing on the area that indicates the most variation in the reflection coefficients, we will see that the variation is small that is about 0.15 dB. and 0.9, respectively. It means that the reflection coefficient alone is not suitable for detection the tumors in the our simulation.

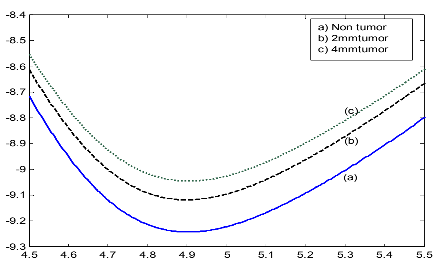

Fig.1. S_{11} for the first dipole

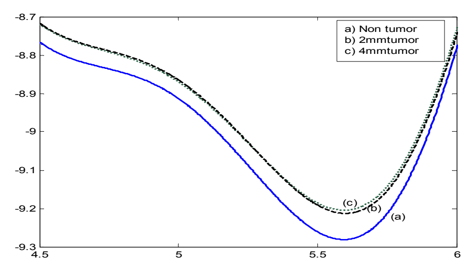

Fig.2. S_{22} for the second dipole

2. Transmission Coefficients:

New kinds of perturbation in the attenuation and the frequency shift are shown clearly in the response of the S_{12}. Fig.3 shows the responses of S_{12} between the first and the second dipoles with 35mm. The tumor with 2mm as a diameter will cause a clear shift that is approximately equals to 20MHz, and changes the attenuation from -54 to -52dB as shown in Fig.3b. Increasing the diameter of the tumor will cause more perturbation especially in the shifted frequency. This is shown clearly in Fig.3c.

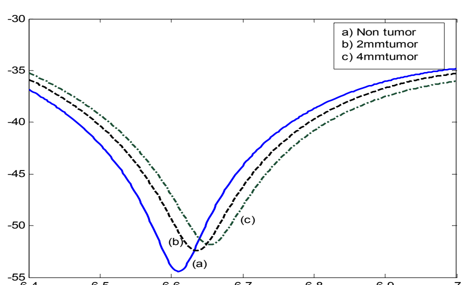

Fig.3. S_{12} between the first and the second dipoles

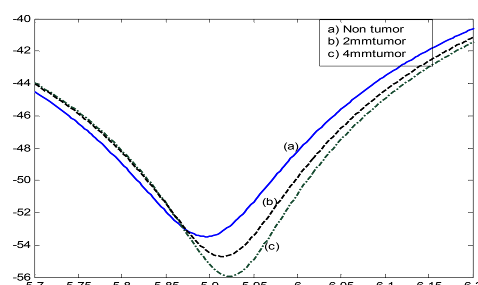

Fig.4. S_{23} between the second and the third dipoles

Using the ultra-wide band with the frequency range from 4.5 to 7GHz, gives us a good chance to study the best range of frequencies that gives the clearest change for all S-parameters, where the positions of the perturbations for the S-parameters differ from antenna to another and between the two antennas..

For example, as studying the transmission coefficients, S_{12} and S_{23} between the dipoles, the position of the perturbation changes from 6.6GHz (as in Fig.3) to 5.9GHz (as in Fig.4) that indicates the importance of using UWB as a diagnosing tool.

b) Changing the position of the tumor

In this model, the proposed dipoles configuration stated its ability to detect the tumor regardless its position. This enables us to minimize the movement of the array many times through our skin to detect the tumor.

Figs.5and 6 show samples of the S-parameters as changing the position of the tumor between the dipoles. The tumor with 2mm in radius can be detected as changing its position between the first and the second dipoles. These positions are: under the first dipole, 15 mm from the first one and 25mm from the first dipole. Small variations in the reflection coefficients are shown as compared to its position under the dipoles directly.

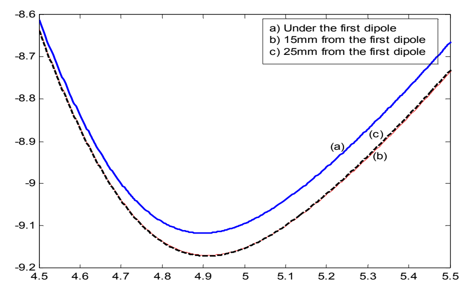

Fig.5. S_{11} for the first dipole

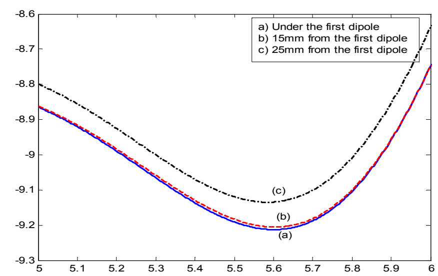

Fig.6. S_{22} for the second dipole

For measuring the ability of UWB to detect the tumor with smaller sizes at more depths, we minimize the thickness of the tumor to be 2mm, insert it at 15mm from the first dipole and increase the depth to be 3mm deeper than the normal cases

Figs.7 shows the transmission coefficients between the first and the second dipoles, S_{12}. the frequency range from 6.5 to 6.7GHz shows a clear perturbation that has been done on the response of S_{12} as compared to the non-tumor case (Fig.7a). This perturbation is directly in the frequency, where the response seemed to be shifted as the tumor is inserted in this model.

Inserting this tumor affects also on the response of S_{23} that relates to larger distance between the dipoles (45mm). This effect is not only in the frequency shift but also on the amplitude of S_{23} along the frequency response. This is shown clearly in Fig.8.

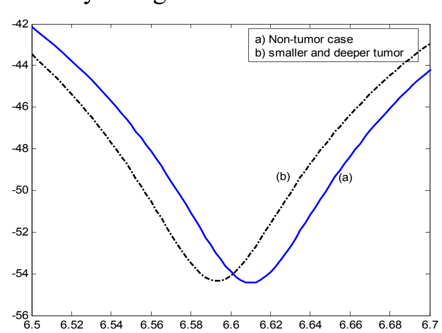

Fig.7. S_{12} between the first and the second dipoles

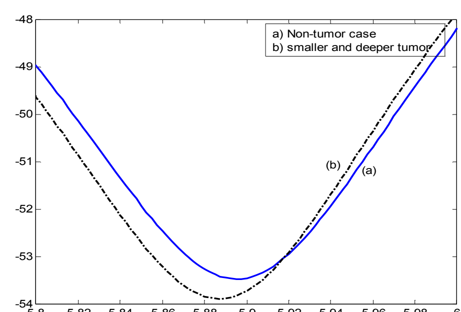

Fig.8. S_{23} between the first and the second dipoles

From the collected results, we show that using UWB with this wide frequency band enables us to detect the tumor from different sides. From the responses of the reflection coefficients and the transmission coefficients. Each with separated frequency responses. So we can summarize the detection process as a collection of different filters each case has its individual one. Finally, the decision will be the collection from all responses as shown in Fig.9. The most effective parameters are S_{11} , S_{12} , S_{22} and S_{23} not the only reflection coefficient as in [6,7]. The returned signal for each parameters will be filtered with a certain filter depending on the results.

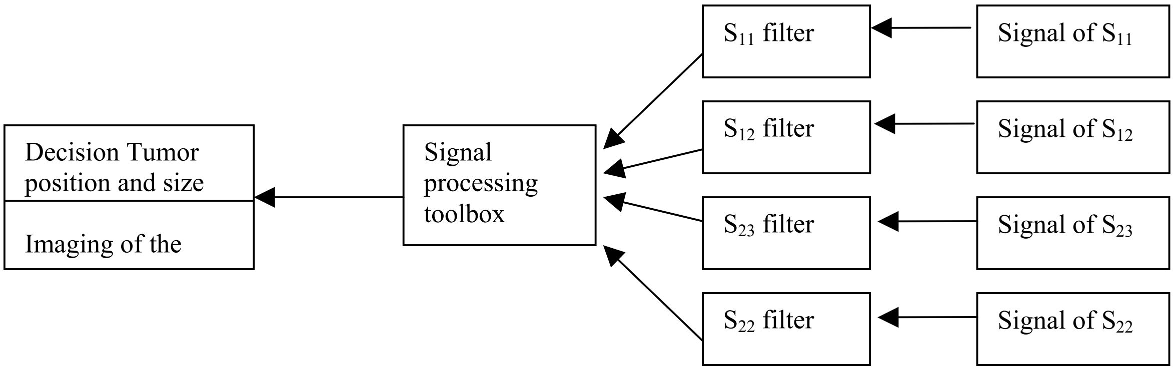

Fig.9. The proposed process for detection and imaging the tumor correctly

4. Conclusion

This paper presents the proposed model for the tumor inside the human tissue. The variation in the electric parameters for the tumor as compared to the parameters of the human tissue enables us to detect it. Using the ultra/wide band with this wide band improves the resolution of detection of these tumor, where the decision here depends on more than one parameters. Each one of the scattering parameters proves that it can detect the tumor alone. But using these collections improves the resolution and so the decision.

References

[1] Seong G. Kong, Matthew E. Martin, and Tuan Vo-Dinh, ‘’ Hyperspectral Fluorescence Imaging for mouse skin tumor detection’’, ETRI Journal, Volume 28, Number 6, December 2006.
[2] Christine N.Paulson, John T. Chang, Carlos E.Romero, Joe Watson, FJ Pearce, and Nathan Levin., ‘’Ultra-wide Radar Methods and Techniques of Medical sensing and Imaging’’., SPIE International Symposium on Optics East, Boston, MA, United States, October 2005.
[3] http://www.fcc.gov/
[4] Bilich, Carlos, ‘’Feasibility of Dual UWB Heart Rate Sensing and Communications under FCC power restrictions’’. In Proceedings UWB Radio Technology Workshop / IET Symposium on UWB, Genoble, France., 2007.
[5] H.M.Jatari, W.Liu, S.Hranilovic, and M.J.Deaen., ’’ Ultra wide band radar imaging system for biomedical applications’’., American Vacuum Society, Jun 2006.
[6] Wee Chang Khor, Marek E. Bialkowski, Amin abbosh, and Norhudah Seman,’’ An Ultra Wideband Microwave Imaging System for Breast Cancer Detection’’ IEICE Trans Commun., vol.E90-B, No.9 September 2007.
[7] X.Zhuge, M.Hajian, A.G.Yarvoy, and L.P.Ligthart, ’’Ultra-Wideband Imaging for Detection of Early Stage Breast Cancer’’., Proceeding of 4th European Radar Conference. Munich, Germany 2007.
[8] Italian National Research Council, Dielectric properties of body tissue. Available:http//niremf.ifac.cnr.it/tissprop/.