IJCTA, 9(10), 2016, pp. 4921-4934

UWB Imaging Technique is a Tool to Detect Early Breast Tumor : A Review

***A. Naveena Lakshmi *Reddy Prasad D.M. **S.Thirumurugan**

Abstract : Breast cancer is the second leading cause of cancer deaths among women, after lung cancer. In this paper, some of breast cancer detection techniques such as Mammography, Magnetic Resonance Imaging (MRI), Ultrasonography, Ultra Wide Band (UWB), Microwave imaging, etc. and their performances have been reviewed. Most of the techniques have some drawbacks, e.g., invasive, painful, and costly as well as having ionized radiation, etc. Presently, UWB microwave imaging systems gained more attraction due to its non-ionization nature, but have some limitations such as the inability to detect early stage tumor, complex systems with multiple antennas, lack of 3D tumor representation etc. The limitation details of the existing and proposed systems is given with a thorough investigation, and finally it's followed by expressing some open issues which are needed to be resolved to overcome these limitations.

Keywords : Ultra Wide-band, Breast Cancer, Tumor Detection, Dielectric properties.

1. INTRODUCTION

Currently, cancer is one of the leading causes of mortality with more deaths per annum than heart disease among those under 85 years of old (Globocan 2002). Breast Cancer is one of the main causes for women's death in all over the world (Gail et al., 1989). Worldwide around 50% of breast cancer cases end up with death. The percentage is high because the detection of cancer is typically very late. The early detection of tumor could help to reduce the higher percentages of death cases (Seidman et al., 1982) and thus save a lot of lives.

There are two kinds of breast tumors: noncancerous (benign) tumors and cancerous (malignant) tumors. Benign breast tumors are growing very slowly and do not spread outside the breast in which they appear. Malignant breast tumors are made up of cells that can spread from the breast to other parts of the body very rapidly.

There are several types of breast cancer. In many cases, breast cancer starts in the ducts or lobules of the breast (where milk can be produced) as shown in the Figure.1. In the early stages of breast cancer, breast tumors found in these ducts are called "in situ", meaning that they are in one location and are noninvasive. Invasive breast cancer means that the cancerous breast tumor has broken through the wall of the ducts or lobules and spread to other parts of the body (Southern Cross Health care Group 2006).

The Singapore Cancer Registry (Breast Health Information Center, 2008) also reported a lower incidence of breast cancer within Malay women compared to Chinese and Indian women. Singapore has recorded a rising trend of 3.7% per annum in the incidence rate of breast cancer from 1968 to 1997. The age-specific incidence shows a peak in the 40-49 year age group and then, a decline. This is unlike the age-specific incidence curve of American women (Breast Health Information Center, 2008), which rises rapidly until the age of 50 years and then, the curve continues to rise but slowly.

* Petrolem and Chemical Engineering, Faculty of Engineering, Universiti Teknologi Brunei, Tungku Highway, Gadong, BE1410, Brunei Darussalam.

** Department of Information Technology, College of Applied Sciences Sohar, Sohar, Oman PC311

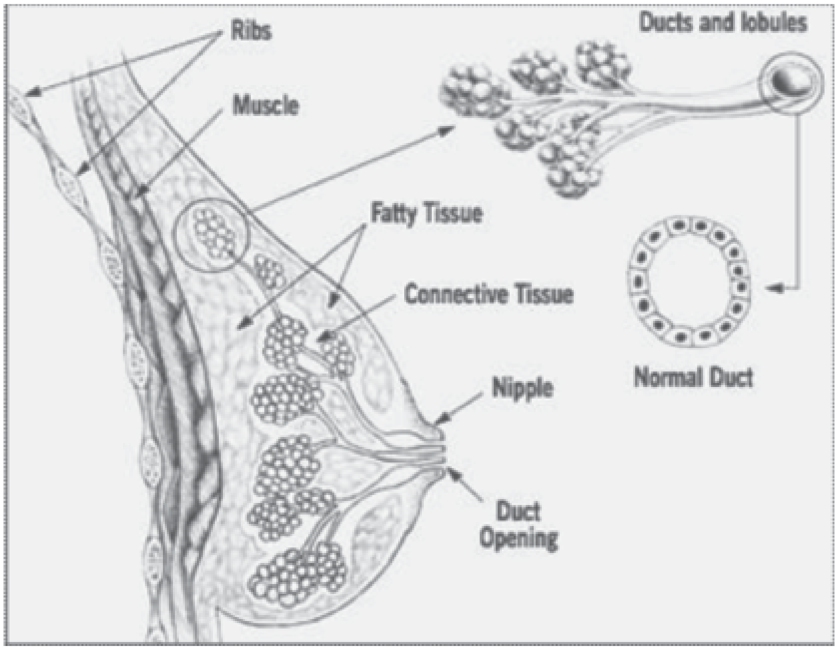

Fig. 1. Side view of the breast.

Breast cancer is the most frequent one of related death for women in both developed and developing countries (Globacan 2008). The estimated number of deaths globally due to breast cancer in 2008 was 458367. Mortality rates show less geographical variation compared to incidence rates because of the more favorable survival of breast cancer in regions with high incidence rates. The world standardized mortality rate for breast cancer is 12.5 per 100000 and ranges from 17.5 per 100000 in Western Europe to 6.3 per 100000 in Eastern Asia, as shown in Figure.2.

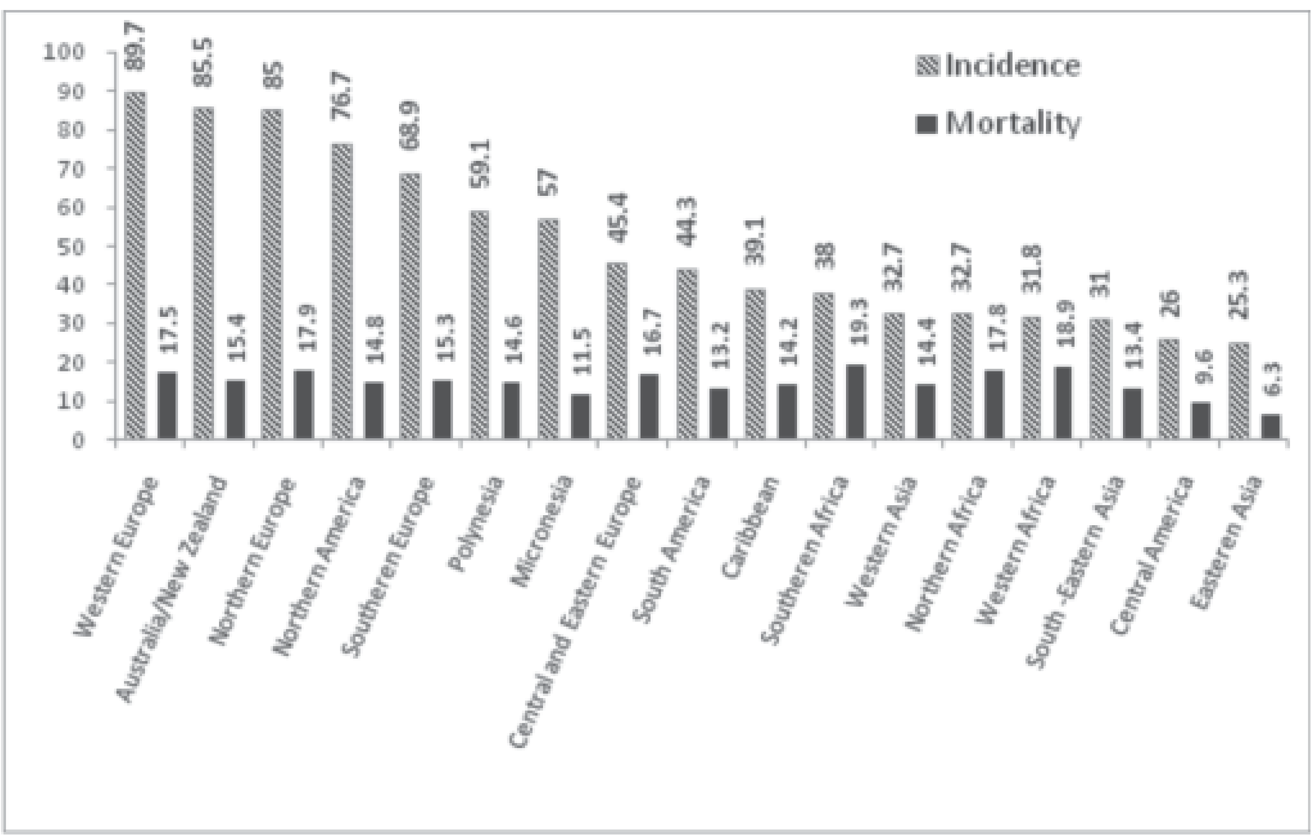

Fig. 2. Age standardized incidence and mortality rates for breast cancer worldwide per 100000 in 2008.

The present standard screening method for detecting nonpalpable early-stage breast cancer is X-ray mammography. Despite the fact that X-ray mammography provides high resolution images using relatively low radiation doses, its limitations are well documented, especially in radiological dense glandular tissue (Nass. et al., 2001). A number of research works examining the capabilities of emerging imaging modalities for breast cancer detection has been conducted. The investigation for new imaging techniques was motivated by the need for increased sensitivity and specificity in younger women. Some of the affected breast tissues in the breast, containing higher dense-to-fatty tissue ratio, and suspicious lesions in dense tissue are likely to be missed by X-ray mammography (Bird et al., 1992). In U.S., approximately 15% of all breast cancers are missed by conventional mammography, while 75% of all malignancies identified are found to be benign after biopsies (Hall et al., 1998).

In addition to this, it has been shown that traditional mammography results in a high rate of false positives, resulting in unnecessary biopsies and considerable distress to the patient (Elmore et al., 1998). Similar kinds of issues also exist with the obvious alternatives to X-ray mammography such as MRI and ultrasound imaging. Although MRI has a negative predictive value (NPV) of 99%, the cost and sensitivity of these alternative imaging modalities are well documented, and preclude their widespread use (Lehman et al., 2007; Viehweg et al., 1998; Kacl et al., 1998; Staren and Neill 1982). NPV is defined as the proportion of subjects with a negative test result who are correctly diagnosed. One of the most promising alternative imaging modalities is UWB microwave imaging. The physical basis for microwave imaging is the significant dielectric contrast between normal and malignant breast tissues that exists at microwave frequencies.

This dielectric contrast between normal and malignant tissues ensures that tumor presence in the breast will provide backscattered energy. It may be used to detect the presence of the tumor when illuminated by microwave radiation. The UWB radar imaging uses the reflected signals to determine the location of significant microwave scatters. Microwave imaging is non-ionizing, does not require breast compression, is less invasive than x-ray mammography, and low cost.

The paper is organized as follows. The next section presents the detailed investigation of various breast tumor detection techniques. It's followed by tissue di-electric properties, major role of UWB imaging to detect early breast tumor, comparison of various methods and finally conclusion, respectively.

Breast tumor detection techniques

Mammography

Mammography as the standard imaging method for breast cancer screening has resulted in reduced breast cancer mortality (Shapiro et al., 1982). However, the number of cancers undetected through mammography is substantial, particularly for women with dense breast tissue, with sensitivity as low as 30–48% (Mandelson et al., 2000). The Computer-Aided Detection (CAD) improves sensitivity but does not identify all cancers (Dean and Ilvento, 2006; Ho and Lam, 2003). The Digital Mammographic Imaging Screen Trail (DMIST) found an improvement from 55% to 70% in cancer detection compared to film mammography (Pisano et al., 2005). Even though there is a substantial number of undetected cancer cases with digital technology, mammographically missed cancer is a particular problem for women with dense breasts. Boyd et al., 2007 showed that extensive mammographic density was strongly and reproducibly associated with an increased risk of breast cancer. They also found that this increased risk persisted for an extended period of time particularly in younger women with dense breasts compared to fatty breasts. So, their suggestion is to develop an alternative imaging technique for such women. The performance of mammography is reduced for cancer detection in dense breasted women as mammograms are summation images, with all breast tissue overlapping in each view. Cancers may not be visualized because of overlying dense breast tissue (Bird et al., 1992). Mammography can miss far posterior cancers in the retro-mammary space because of inadequate for imaging those deeper tissues. Although this method is very popular, it has some disadvantages (Birdwell et al., 2001).One of the main drawbacks is the high miss detection which can reach 30% (Huynh et al., 1998) with high positive and high negative detection. In some cases, it cannot detect if the tumor size is too small and unable to differentiate between malignant and benign tumors. The main drawback is, it is painful for the patients, harmful for human tissue and it is not recommended to be used on patients under 40 years old (Saslow et al., 2007).

The current leading method of detection for this type of cancer is mammography in which the breast is exposed to low-power X-ray mammography, and a resultant image is formed. This method has problems such as high false negative rates, high false positive rates, and the ionizing nature of X-ray mammography which poses a considerable risk of causing the very cancer it attempts to detect. There are various passive and active microwave techniques which have been proposed as an alternative to the most widely used X-ray mammography for early detection of breast cancer, such as microwave radiometry, hybrid microwave-induced acoustic imaging, and microwave tomography beside the UWB microwave radar technique. Passive methods use radiometers to measure the temperature differences in the breast as temperature increases in the presence of tumor than with healthy breast tissue (microwave radiometry). The hybrid method use microwave energy to heat tumors. They expand and generate pressure waves which are detected by ultrasound transducers.

In microwave tomography, a nonlinear inverse scattering problem is solved to reconstruct an image of the dielectric properties in the breast. In contrast to the image reconstruction aim of the microwave tomography technique, UWB radar-based imaging approach solves a simpler computational problem faster dealing with only to identify the presence and location of significant scattering obstacles such malignant breast tumors." [Ý. Ünal et al., 2011]

Magnetic resonance imaging

Magnetic Resonance Imaging (MRI) is costly and has recently been recommended by the American Cancer Society (ACS) to screen women at very high risk of breast cancer (Lin and Brown, 2007). Who have a high probability of having breast cancer through initial investigation (Griebsh et al., 2006) for breast cancer screening also been characterized by lower specificity compared near mammography with a higher rate of false positives, misdetection leading to further follow up MRI and image guided biopsy. MRI specificity is about 81%, compared to 93% specificity in mammography (Leach et al., 2006). Because of lower specificity and higher cost, compared to mammography, MRI may not be optimal for breast cancer screening. In a study performed on women with a high risk factor for cancer, over 15%, the sensitivity of MRI was estimated to be 71.1%, compared to 40% for mammography and 17.8% for clinical breast examination (Libermanet al., 1998).

Ultrasound

Ultrasound is an attractive supplement to mammography because it is widely available, relatively inexpensive and well-tolerated by patients (Parker et al., 1993). Early reports using high-resolution ultrasound for breast cancer detection has shown promising results (Benson et al., 2004; Berg et al., 2004; Crystal et al., 2003; Buchberger et al., 1999), but to detect nonpalpable tumors by this technique required high skill and longer time, and that is why the technique is not used (Kopans et al., 1999). Berg et al., 2008 also noted that the lack of uniformity and shortage of qualified personnel limit wide implementation of hand held imaging. Previous studies have shown that 3Dautomated Whole Breast Ultrasound (AWBU) is feasible (Destounis et al., 2005).The 3D AWBU has been excellent interobserver variability with 2D benign and malignant lesions (Wenkel et al., 2008). However, the main disadvantage is its disability to produce high resolution for deep and condensed tissue structure such as fatty tissues (Kaplan et al., 2001; Crystal et al., 2003). Ultrasound results may identify a potential area of concern that is not malignant. These false-positive results could lead to more procedures, including biopsies that are not necessary. Although ultrasound is often used in an attempt to prevent an invasive measure for diagnosis, sometimes it is unable to determine whether or not a mass is malignant, and a biopsy will be recommended. Many cancers cannot be detected via an ultrasound (Breast Ultrasound, 2007).Preliminary data from a trial being conducted showed that there was a higher rate of false-positive results with ultrasounds than with mammography stated as 2.4%-12.9% for ultrasound and 0.7%-6% for mammography (Elmore et al., 2005).

Full UWB imaging

Microwave Imaging is an emerging technique for several biomedical imaging applications. Microwave signals are one of the non-ionizing form of electromagnetic waves and thus do not incur health hazard when used at low levels. The main question regarding the efficiency of UWB microwave imaging for breast cancer detection is its accuracy. In recent years, there have been developed some techniques including confocal (Fear et al., 2002), beam forming(Davis et al., 2003), time reversal (Kosmas and Rappaport et al., 2006), and Distorted Born Iterative Method (Winters et al., 2009).Microwave detection is less expensive and safer than other forms of detection and also noninvasive. For these reasons, this method has been increasingly recommended as a regular examination and detection tool for early breast tumor detection, but it is under medical trials and improvement stage till today.

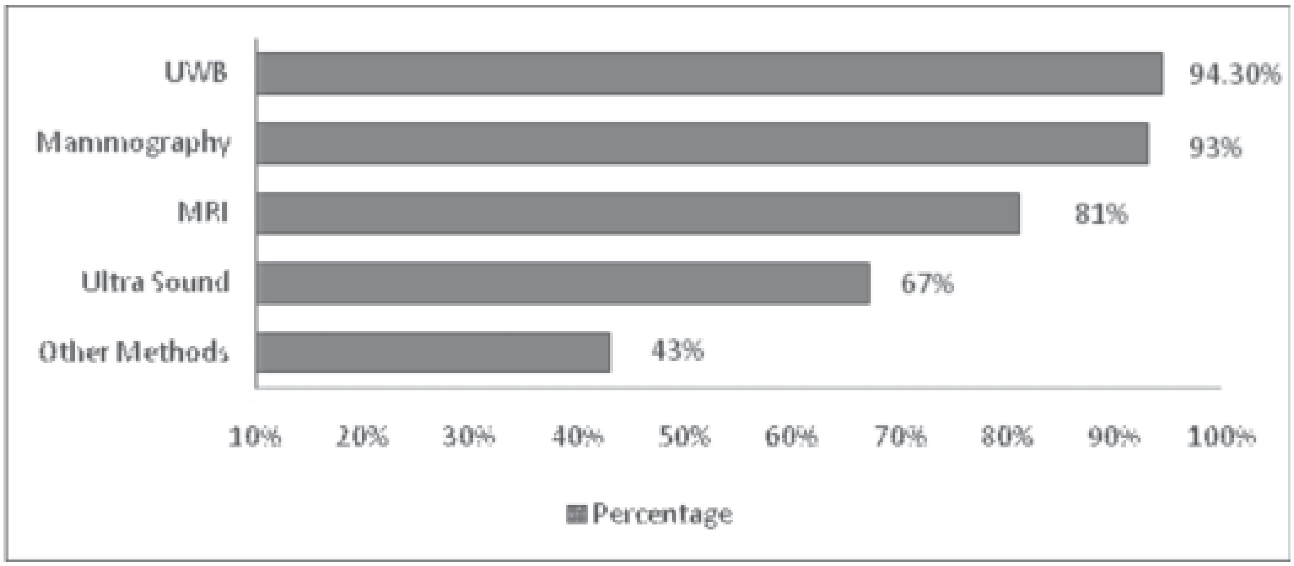

Fig. 3. Performance of Techniques(Alshehri et al., 2009, 2011,Leach et al., 2006,Bonnema et al, 1997; De Kanter et al, 1999,).

In Figure.3, detection performance among the various techniques is presented. The other methods given in the figure are Molecular Breast Imaging (MBI), Positron Emission Mammography (PEM), and nuclear medicine imaging procedure of the breast called scintimammography. Although UWB shows better results than the other techniques, it requires a more feasible system for detection in clinical trials to prove its specificity as so far it is only under research and investigation stage.

Di-electric properties:

The physical basis for microwave breast cancer detection is the dielectric-properties contrast between malignant and normal breast tissue. The Wisconsin-Calgary study (Lazebnik et.al. 2008) showed that this contrast is as high as 10:1 in fatty breast tissue but no more than 10% in fibroglandular tissue. A comprehensive review of the dielectric properties of normal and cancerous breast tissue and the heterogeneity of normal breast tissue has been presented in this section.

Campbell and Land, 1992 measured the complex permittivity of female breast tissue at 3.2GHz using the resonant cavity technique. Their specific aims were to provide detailed dielectric properties measurements at 3.2GHz for microwave thermography applications. Four types of tissue were examined by them as fatty tissue, normal tissue, benign breast tumor tissue and malignant breast tumor tissue. The results are outlined in Table.1. They noted a significant dielectric contrast between normal (fat tissue and all other breast tissues) and tumorous tissue. They also suggested that due to the similarity in dielectric properties of malignant and benign tumors, it may be impossible to distinguish between the two based on dielectric properties alone. They noted much greater variance in the dielectric properties of normal tissue than suggested in other previous studies.

Table 1. Dielectric properties of female breast tissue at 3.2GHz (Campbell and Land, 1992)

Tissue Type	*Relative Permittivity (εr)*	*Conductivity(S/m)*	*Water content(%)*
Fatty Tissue	2.8-7.6	0.54-2.9	11-31
Normal Tissue	9.8-46	3.7-34	41-76
Benign tissue	15-67	7-49	62-84
Malignant Tissue	9-59	2-34	66-79

Meaney et al., 2000, used a clinical prototype of a tomographic microwave imaging system to estimate the dielectric properties of normal breast tissue. The average permittivity and conductivity of cancer free breast tissue and the results are shown in Table.2. He noted that the average permittivity values of normal tissue at 900MHz are significantly higher than those previously published studies (Joines et al., 1993; Chaudhary et al., 1994).

Table 2. Average dielectric properties of female breast tissue at 900MHz measured in vivo using an active microwave imaging system (Meaney et al., 2000).

Patient	*Age*	*Average Permittivity (εr)*	*Average Conductivity (S/m)*
1	76	17.22 ± 11.21	0.5892 ± 0.3547
2	57	31.14 ± 4.35	0.6902 ± 0.3650
3	52	36.44 ± 6.24	0.6869 ± 0.3156
4	49	35.43 ± 3.93	0.5943 ± 0.3841
5	48	30.85 ± 7.22	0.6350 ± 0.3550

Xie et al., 2006 was developed a 3D hemispherical FDTD model of the breast. The hemisphere was 100 mm in diameter, surrounded by a 2 mm layer of skin. The nipple and the chest wall were also included in the model. To reduce reflections from the skin, the breast model is immersed in a lossless liquid with a permittivity value similar to that of breast tissue. The heterogeneity of breast tissue is modeled by assuming the dielectric properties to be Gaussian random variables with variations of ± 10% around the average values.The dielectric properties of breast tissue used by Xie et al., 2006 are described in Table.3.

Table. 3. Dielectric properties of breast tissue (Xie's et al., 2006) at 6 GHz

	Tissue	*Relative Permittivity (εr)*	*Conductivity (S/m)*
Xie's (2006)	Immersion Liquid	9	0
	Fatty Breast Tissue	9	0.4
	Chest Wall	50	7
	Skin	36	4
	Nipple	45	5
	Glandular Tissue	11-15	0.4-0.5
	Tumor	50	4

The dielectric property of the tumor tissue varies with the change of frequency while it remains almost constant for the healthy and fat tissues. This property motivates the use of frequencies 4 and 8 GHz as center frequencies (Alshehri et al., 2009, 2011). He used different ratios of water to wheat flour to form the tumor. Dielectric properties of breast tissue are shown in Table.4. The different Signals correspond to various dielectric property values are generated to train the Neural Network (NN).

Table. 4. Dielectric properties of female breast tissue (Alshehri et al., 2009, 2011)

	Tissue	*Conductivity (S/m)*	*Relative Permittivity (εr)*
Alshehri (2009)	Skin	1.49	37.9
	Fat	0.14	5.14
	Chest	1.85	53.5
	Tumor	1.20	50.0
Alshehri (2011)	Fatty Breast tissue	2.36	0.012
	Tumor	15.2-37.3	2.1-4.0
	Skin	3.5-10	Negligible

The variance of the dielectric properties of normal tissue established by Joines et.al 1993 shown in Table 5. In order to reflect this variance, (Hagness et al., 1998) a randomly assigned a square block of grid cells (spanning 5 × 5mm) in the FDTD model with a permittivity value and a conductivity value in a ±10% range is centered around the nominal values in a checkerboard pattern.

Table. 5. Dielectric properties of female breast tissue (Joines et al.1993)

	Tissue	*Permittivity variance*	*Conductivity variance*
Joines (1993)	Normal Tissue	± 5%	± 7%
	Malignant	± 7%	± 9%

Major role of UWB imaging to detect early breast tumor

Over the past few years, several research groups have been working on both hardware and software aspects of microwave breast imaging to take advantage of the high contrast of healthy and malignant tissue at microwave frequencies. The reason for the high contrast between malignant and normal tissue can be better understood through a brief examination of the frequency dependent electrical properties of biological tissue (Joines et al., 1980; Meaney et al., 1999; Fear et al., 2003). Several microwave imaging techniques have been suggested, including microwave tomography and confocal imaging.

UWB radar imaging, as proposed by Hagness et al., 1998, 1999 uses reflected UWB signals to determine the location of microwave scatters within the breast. This is a similar imaging procedure to that used in surface-penetrating radar rather than using the tomographic approach of reconstructing the entire dielectric profile of the breast. UWB radar imaging uses the Confocal Microwave Imaging (CMI) approach to identify and locate regions of scatterers within the breast (Daniels et al., 1996, Fear et al., 2002; Li. et al., 2001; Bond et al., 2003; Xie. et al., 2006; Guo et al., 2005). A recent study of the dielectric properties of adipose, fibroglandular and cancerous breast tissue has highlighted the dielectric heterogeneity of normal breast tissue (Lazebnik et al., 2007). In normal breast tissue being primarily homogeneous, a very significant dielectric contrast between adipose and fibroglandular tissue within the breast is found. The dielectric property of adipose tissue was found to be lower than any previously published data for normal tissue. This heterogeneity of normal breast tissue had been considerably underestimated in more historical studies, and the difficultly this presents to exist data-independent beamformers has been examined by the authors previously (Halloran et al., 2009)

Chen et al., 2007, 2008, studied the effect of the morphology of different tumors on the late-time response of backscattered signals obtained from the FDTD breast model. In these studies, the 2D models of benign and malignant tumors were created using an approximation to irregular polygons, with an elliptical baseline. It had been used by to circumscribe different breast tumors in X-Ray mammographies (Rangayyan et al., 1997). Chen et al also developed an algorithm that allows for the location of a tumor and indicates, by means of a correlation, whether the lesion boundary is more or less irregular, possibly indicating whether a tumor is benign or malignant. In 2010, he analyzed the issue of classification after applying a contrast-agent to lesions in order to increase the contrast between cancerous and normal breast tissue. Recently, AlShehriet al., 2009 proposed a simple feed-forward back-propagation Neural Network (NN) model, which successfully detected up to 0.25cm tumor. In 2011, they used operation frequency 4.7GHz and detected tumor size 100 µm in CST simulation and 1 mm in experiment. Yusoff et al., 2009 proposed absorption loss model of UWB signal by the body (Breast) tissue, which is very useful to determine the propagation range of UWB signal through the breast tissue.

Current UWB imaging using NN has some limitations. UWB imaging technique is unable to detect and locate a very small sized tumor and it needs more dimensionality (AlShehri et al., 2009). Extracting useful information from the received signal is also another challenging task. The pattern recognition tools like NN may turn to a solution but still choosing the right feature vector is important. Also, a variety of UWB antenna and antenna arrays had also been extensively studied to improve the collection of backscattered signals (Li et.al, 2003; Zhao et al., 2004). They provided good results under certain conditions, but most are not efficient in terms of computation time. Similarly, more complex antenna structures (and arrays) increase cost and complexity of the system. Hence to achieve accurate detection of tumor size and location using a simple antenna and (Discrete Cosine Transformer) DCT is a challenge in recent years. Research has to be done to make a better system which used UWB signal to detect early breast cancer efficiently. In all the systems, there are no pictorial 3D representations of the tumor size. The work needed to be conducted in real time with real patients in terms of clinical test.

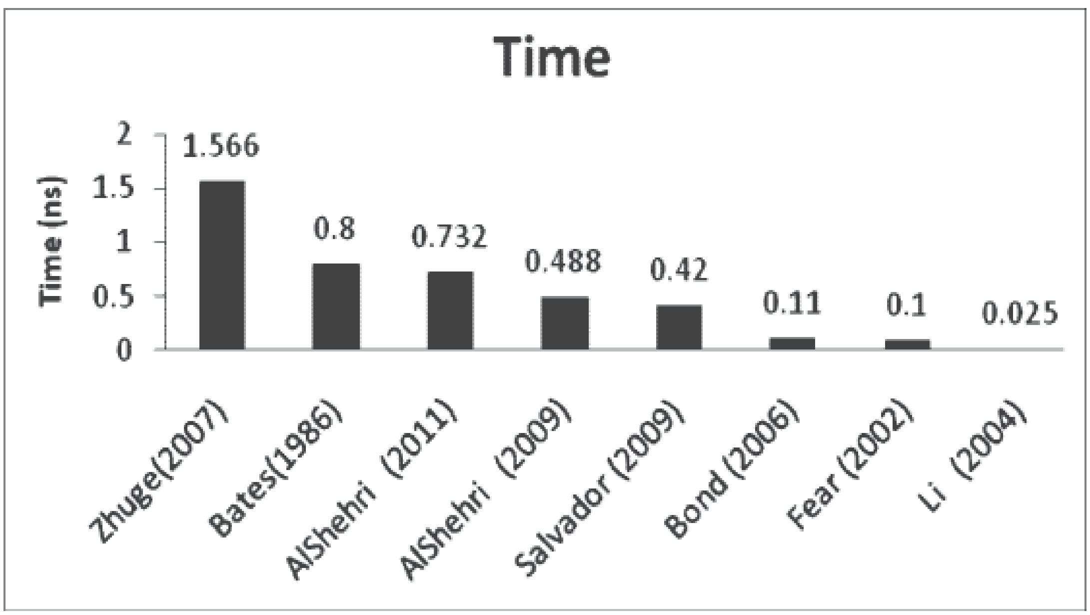

Fig. 4. Comparison of detection time by various researchers

The tumor detection delay compared among various methods (Zuhuge et al., 2007; Bates et al., 1986; Alshehri et al., 2009, 2011; Salvador et al.,2009; Bond et al., 2006; Fear et al., 2002; Li et al.,2004) shown in Figure.4 reviles that Liet al., 2004 detect the tumor in the shortest time (0.025 ns).

A comparison between the techniques in terms of tumor size, frequency and number of used antennas is presented in Table 6. It can be seen the UWB technique which used as 4.7 GHz (AlShehri et al., 2011, Siti Hasmah et al., 2015) can detect the tumor size up to 1mm through experiment, whereas 100 µm through simulation. However, reducing the number of antennas to detect the tumor is also one of the important tasks in the breast cancer.

Comparison between various Methods

Table 6. Comparison in terms of Tumor size, Used Centre Frequency and number of antennas

Researchers	*Tumor Size*	*Centre Frequency*	*No. of Used antennas*
Li and Hagness,2001	2.5 mm	1 GHz	17
Sill and Fear, 2005	20 mm	4 GHz	—
Yifan Chen ,2006	2 mm	6 GHz	13
Bond et al., 2006	2mm	6 GHz	—
Tavassolian et al., 2007	2mm,4mm,6mm	6 GHz	16
Klemm et al., 2007	4mm, 10mm	6 GHz	16
Klemm et al., 2008	7mm,10mm	6 GHz	—
Hooi Been Lim et al., 2008	5mm	7 GHz	7
kubota et al., 2008	20mm	15 GHz	10
Maskooki et al., 2009	2mm, 5mm	8 GHz	24
Conceicao et al., 2009	6 mm	7.5 GHz	22
Wee Chang Khor et al., 2009	5mm	3.1 GHz	—
Xia Xiao et al., 2009	6 mm	6 GHz	7
AlShehri et al., 2009	2.5 mm,3 mm	4 GHz, 8 GHz	2
Klemm et al., 2010	10 mm,20 mm	7 GHz	31
Halloran et al., 2010	6 mm,10 mm	7.5 GHz	—
Deprezet al., 2010	7 mm	7.5 GHz	31
Byrne et al., 2010	2.5 mm, 5mm,7.5 mm	7 GHz	53
Bialkowski et al., 2010	6mm	6 GHz	16
Byrne et al., 2011	2 mm,4mm,5 mm, 10mm,15mm	3.8 GHz	4
Conceicao et al., 2011	5 mm	3.57 GHz	—
Bingyu Liu et al., 2011	6mm	5 GHz	7
Wenyi and Adams et al.,2011	3mm	3.2 GHz	32
Byrne et al., 2011	4mm	3.8 GHz	4
Tonny Rubak et al., 2011	10mm,8mm	1.2 GHz	20
Alvaro Diaz et al., 2011	10mm,8mm	2.45 GHz	44
AlShehri et al., 2011	1mm	4.7 GHz	2

Open Issues and Discussion

At present, Ultra Wideband (UWB) imaging is under high demand due its non-destructive nature for biomedical application and screening such as breast cancer detection. To find its effectiveness and prior to clinical trial experimentation is needed through some alternative equivalent tissue medium (phantom). A near optimum breast phantom (close to real human tissue and the tumor) is essential besides other devices to conduct an experimental work for early breast cancer detection. Appropriate UWB-friendly phantom (or any proper material investigation results) is not available. So far researchers performed their experiments with various types of non-realistic phantoms most of which are homogeneous using some oil as fatty tissue and PVC or similar materials as tumors. Some phantoms are proposed but either costly or difficult to build or not.

Towards this goal, in 2011, Alshehri et al. investigated on affordable and easily obtainable construction materials followed by development and fabrication of tumor, homogeneous and glandular breast phantoms close to human tissue. These phantom prototypes can be developed with minimal cost, effort and time duration without any other processing by using some combination of the available materials (soya, wheat flour, Vaseline etc.). This phantom is one of the most significant recent developments in this area for UWB frequency range (3.1 to 10.6 GHz). This may influence the process of breast cancer investigation research in a faster way for physical clinical use. They also proposed a good technique using only one pair of antennas with high detection ability. The detection performance was confirmed through the experiment using their developed phantoms.

From the investigation of all UWB researches the open issues are to find non-invasive, non-ionizing, user friendly and affordable techniques/systems to detect breast tumor in very early stage. The system could be used repeatedly as per need to detect the tumor details (existence, size, location, type, etc.) without any harmful effect on the human body. Hence UWB is the better choice in this regards and a sophisticated UWB system is in demand with clinical trials.

2. CONCLUSION

Investigation details on early breast tumor detection and related techniques are presented in this paper with open issues. Advantages and disadvantages have been described. The result of the different author's has been shown in perspective of detection time, frequency and tumor size. To overcome the limitations of the proposed solutions, it is found that UWB technique is the appropriate for the detection because of its non-ionizing nature, does not require breast compression, non-invasive, and low cost. The open issues are to investigate a new UWB imaging technique for early breast cancer detection to reduce dimensionality and enhance the Artificial Intelligence (AI) system through a real time experiment.

3. REFERENCE

1. Ahmedin Jemal, Rebecca Siegel, Elizabeth Ward, YongpingHao, JiaquanXu, Taylor Murray, Michael J. Thun (2008). Cancer Statistics. CA Cancer J Clin 58:71-96.
2. AlShehri S. A, Khatun S, Jantan A. B, Raja Abdullah R. S. A, Mahmood R, Awang Z (2011). Experimental Breast Tumor Detection Using NN-Based UWB Imaging. Progress In Electromagnetics Research. 111:447-465.
3. AlShehri S. A, Khatun S, Jantan A. B, Raja Abdullah R. S. A, Mahmood R, Awang Z (2011). 3D Experimental Detection And Discrimination Of Malignant And Benign Breast Tumor Using NN-Based UWB Imaging System. Progress In Electromagnetics Research.116:221-237.
4. AlShehri S. A., Khatun S (2009). UWB imaging for breast cancer detection using neural network.Progress In Electromagnetic Research C. 7:79-93.
5. Alvaro Diaz-Bolado, Paul-Andre Barriere ,Jean-Jacques Laurin (2011). On the Effect of Breast Compression and Measurement Setup Conûguration in Microwave Tomography for Breast Cancer Detection. 2011 IEE International Symposium on Antennas and Propagation (APSURSI). 1522(3965): 714 – 717.
6. Bates R. H. T, M. J. McDonnell (1986). Image Restoration and Reconstruction Oxford Eng. Science Series. Oxford. U.K.: Clarendon Press.
7. Benson SR, Blue J, Judd K, Harman JE (2004). Ultrasound is now better than mammography for the detection of invasive breast cancer. Am J Surg. 188:381–385.
8. Berg WA, Blume JD, Cormack JB (2008). Combined screening with ultrasound and mammography vs. mammography alone in women at elevated risk of breast cancer. JAMA.299:2151–2163.
9. Berg WA, Gutierrez L, Nessaiver MS (2004). Diagnostic accuracy of mammography, clinical examination, US, and MR imaging in preoperative assessment of breast cancer. Radiology 233:830–849.
10. Bialkowski, M.E (2010). Ultra wideband microwave system with novel image reconstruction strategies for breast cancer detection.Microwave Conference (EuMC). 537 – 540.

11. Bingyu Liu, Xia Xiao, Xu Liu (2011). Ultra-wideband Microwave Image Reconstruction by Robust Capon Beamforming Algorithm for Early Breast Cancer Detection. 2011 International Conference on Control, Automation and Systems Engineering (CASE). 1 – 4.

12. Bird R. E. Wallace T. W ,Yankaskas B. C (1992). Analysis of cancers missed at screening mammograph. Radiology 184: 613–617.

13. Birdwell RL, Ikeda DM, O'Shaughnessy KF, Sickles EA (2001). Mammographic characteristics of 115 missed cancers later detected with screening mammography and the potential utility of computer-aided detection. Radiology. 219:192–202.

14. Bond, E. J., X. Li, S. C. Hagness, B. D. V. Veen (2003). Microwave imaging via space-time beamforming for early detection of breast cancer. IEEE Trans. Antennas and Propagat. 8:1690-1705.

15. Bond, E.J.,VanVeen, HagnessB.D, S.C (2006). Multiple Window Based Ultra-wide band Microwave Imaging for Early-Stage Breast Cancer Detection. Sensor Array and Multi-channel Processing.

16. Boyd NF, Guo H, Martin LJ (2007). Mammographic density and the risk and detection of breast cancer. N Engl J Med. 356:227–36 .

17. Breast Health Information Center (2008), http://www.radiologymalaysia.org/breasthealth/about/FactsNStats.html. (Last access date: 15 October 2011)

18. Breast Ultrasound Radiology Info (2007), [http://www.radiologyinfo.org/en/info.cfm?PG=breastus]. (Last access date: 15 October 2011).

19. Buchberger W, DeKoekkoik-Doll P, Springer P, Obrist P, Dunser M (1999). Incidental findings on sonography of the breast: clinical significance and diagnostic workup. Am J Roentgenol. 173:921–927.

20. Byrne .D, Halloran M. O, Jones. E , Glavin. M (2011). Breast Cancer Detection Based On Differen Tial Ultrawideband Microwave Radar. Progress In Electromagnetics Research M. 20:231-242.

21. Byrne .D, Halloran M. O, Jones. E , Glavin. M (2011). Support Vector Machine-Based Ultra Wide Band Breast Cancer Detection System. J. of Electromagn. Waves and Appl. 25:807-1816.

22. Byrne D, Halloran M. O, Jones E, Glavin M (2010).Transmitter-Grouping Robust Capon Beam-Forming For Breast Cancer Detection. Progress In Electromagnetics Research.108:401-416.

23. Chen, Y., E. Gunawan, K. S. Low, S.-C. Wang, C. B. Soh (2008) .Effect of lesion morphology on microwave signature in 2-D ultra-wideband breast imaging. IEEE T-BME. 55(8):2011-2021.

24. Chen, Y., E. Gunawan, K. S. Low, S.-C. Wang, C. B. Soh,(2007). Effect of lesion morphology on microwave signature in ultra-wideband breast imaging. A preliminary two-dimensional investigation. IEEE AP-S International Symposium, 2168-2171.

25. Chen, Y., I. J. Craddock, P. Kosmas (2010). Feasibility study of lesion classiffication via contrast-agent-aided UWB breast imaging. IEEE T-BME. 57(5):1003-1007.

26. Conceicao R. C, Halloran M. O, Glavin M , Jones E(2011) . Numerical Modelling For Ultra Wideband Radar Breast Cancer Detection And Classification. Progress In Electromagnetics Research B. 34:145-171.

27. Conceicao R. C, Halloran M. O, Glavin M, Jones E (2009). Comparison of planar and circular antenna configurations for breast cancer detection using microwave imaging. Progress In Electromagnetics Research. 99:1-20.

28. Crystal P, Strano SD, Shcharynski S, Koretz MJ (2003). Using sonography to screen women with mammographically dense breasts. Am J Roentgenol. 181:177–182.

29. Crystal P, Strano SD, Shcharynski S,Koretz MJ (2003). Using sonography to screen women with mammographically dense breasts. Am J Roentgenol.181:177–182.

30. Damera A, Evans A J, Cornford E J, Wilson A R M, Burrell H C, James J J, Pinder S E, Ellis I O, Lee A H S ,Macmillan R D (2003). Diagnosis of axillary nodal metastases by ultrasound-guided core biopsy in primary operable breast cancer .Molecular and Cellular Pathology. British Journal of Cancer. 89, 1310–1313.

31. Daniels, D. J (1996). Surface Penetrating Radar IEE Press .London.

32. Davis S. K, Bond E. J, Hagness S. C, Van Veen B. D (2003). Microwave imaging via space-time beamforming for early detection of breast cancer: beamformer design in the frequency domain. Journal of Electromagnetic Waves and Applications.17:357–381.

33. Dean JC, Ilvento CC (2006). Improved cancer detection using computer-aided detection with diagnostic and screening mammography: Prospective study of 104 cancers. Am J Roentgenol 187:20–28.

34. Deprez.J.F, Klemm.M, Smith.P.P, Craddock. I (2010).Twin target correction for ultra-wideband radar imaging of breast tumors. Biomedical Imaging: From Nano to Macro. 213-216.

35. Destounis S, Young W, Hanson S, Somerville P, Murphy P, Zuley M (2005). Automated Breast Ultrasound: A Pilot Study. Radiological Society of North America scientific assembly and annual meeting program. Oak Brook, Ill: Radiological Society of North America.

36. Elise C. Fear, Xu Li, Susan C. Hagness, Maria A. Stuchly (2002).Confocal Microwave Imaging for Breast Cancer Detection: Localization of Tumors in Three Dimensions. IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING. 49(8): 812 – 822.

37. Elmore J. G, Barton M. B, Moceri V. M, Polk S, Arena P. J, Fletche S. W (1998) .Ten-year risk of false positive screening mammograms and clinical breast examinations. New Eng. J. Med 338:1089–1096.

38. Elmore JG (2005). Screening for Breast Cancer. JAMA . 293: 1245-1256. [PUBMED]

39. Fear E. C., Li .X, Hagness S. C., Stuchly M. A (2002). Confocal microwave imaging for breast cancer detection: Localization of tumors in three dimensions. IEEE Transactions on Biomedical Engineering .47:812-812.

40. Fear E.C., Meaney P.M, Stuchly M.A (2003). Microwaves for breast cancer detection? IEEE Potentials 22:12-18.

41. Fear, E. C., J. Sill, M. A. Stuchly (2003). Experimental feasibility study of confocal microwave imaging for breast tumor detection. IEEE Trans. Microwave Theory Tech. 51(3): 887-892.

42. Fear, E. C., X. Li, S. C. Hagness, M. A. Stuchly (2002). Confocal microwave imaging for breast cancer detection: Localization of tumors in three dimensions. IEEE Trans. Biomed. Eng. 49(8):812-822.

43. Fear, E., J. Sill, M. Stuchly (2002). Microwave system for breast tumor detection: Experimental concept evaluation. IEEE AP- S International Symposium and USNC/URSI Radio Science Meeting 1:819-822.

44. Gail MH, Brinton LA, Byar DP (1989). Projecting individualized probabilities of developing breast cancer for white females who are being examined annually. J Natl Cancer Inst 81:1879-86.

45. Globocan (2002). Cancer Incidence, Mortality and Prevalence Worldwide. IARC Cancer Base No. 5. version 2.0, IARC Press, Lyon.

46. Globacan(2008) :http://globocan.iarc.fr/factsheets/cancers/breast.asp

47. Griebsh I, Brown J, Boggis C (2006). Cost-effectiveness of screening with contrast enhanced magnetic resonance imaging vs X-ray mammography of women at a high familial risk of breast cancer. Br J Cancer 95:801–810.

48. Guo. B., Wang .Y, Li J, Stoica P, Wu R (2005). Microwave imaging via adaptive beamforming methods for breast cancer detection. PIERS Online. Hangzhou.China .1(3):350-353.

49. Hagness, S. C, Taflove A, Bridges J. E (1998). Two-dimensional FDTD analysis of a pulsed microwave confocal system for breast cancer detection. Fixed-focus and antenna-array sensors. IEEE Trans. Biomed. Eng. 45(12):1470-1479.

50. Hagness, S. C, Taflove A, Bridges J. E (1999). Three-dimensional FDTD analysis of a pulsed microwave confocal system for breast cancer detection: Design of an antenna-array element. IEEE Trans. Antennas and Propagat. 47(5):783-791.

51. Hall F.M, Storella J. M, Silverstone D. Z, Wyshak G (1988). Non-palpable breast lesions: Recommendations for biopsy based on suspicion of carcinoma at mammography. Radiology 167: 353–358.

52. Halloran M. O, Glavin M, Jones E (2010). Channel-ranked beamformer for the early detection of breast cancer. Progress In Electromagnetics Research. 103:153-168.

53. Ho WT, Lam PWT (2003). Clinical performance of computer-assisted detection (CAD) system in detecting carcinoma in breasts of different densities. Clin Rad 58:133–136 .

54. Hooi Been Lim, Nguyen Thi Tuyet Nhung, Er-Ping Li , Nguyen Duc Thang (2008).Confocal Microwave Imaging for Breast Cancer Detection: Delay-Multiply-and-Sum Image Reconstruction Algorithm.Biomedical Engineering .55(6):1697 – 1704.

55. Huynh, P. T., Jarolimek A. M., S. Daye (1998). the false-negative mammogram. Radiograph. 18:1137–1154.

56. Ý. Ünal, B. Türetken, K. Sürmeli and C. Canbay,(2011).An Experimental Microwave Imaging System for Breast Tumor Detection on Layered Phantom Model”, URSI GASS 2011, 13-20, Ýstanbul, Turkey.

57. Joines W.T, Jirtle R.L, Rafal M.D, Schaefer D.J (1980). Microwave power absorption differences in normal and malignant tissue. Int. J. Radiat. Oncol.Biol. Phys 6:681–687.

58. Kacl G. M , Liu P. F, Debatin J. F, Garzoli E, Caduff R. F, Krestin G. P (1998). Detection of breast cancer with conventional mammography and contrast-enhanced MR imaging. Eur. Radiol 8:194–200 .

59. Kaplan SS (2001). Clinical utility of bilateral whole-breast US in the evaluation of women with dense breast tissue Radiology .221:641–649.

60. Klemm M, Craddock. I, Leendertz J, Preece A , Benjamin R (2008). Improved delay-and-sum beam forming algorithm for breast cancer detection. International Journal of Antennas and Propagation 2008: 9.

61. Klemm. M, Craddock. I.J., Leendertz. J, Preece. A.W, Benjamin. R (2007). Breast Cancer Detection using Symmetrical Antenna Array .EuCAP. 1-5.

62. Klemm. M, Leendertz. J, Gibbins.D, Craddock.I.J, Preece. A, Benjamin. R (2010). Towards contrast enhanced breast imaging using ultra-wideband microwave radar system.Radio and Wireless Symposium (RWS). 516 – 519.

63. Kopans DB (1999). Breast cancer screening with ultrasonography. Lancet 354:2096–2097.

64. Kosmas P, Rappaport C. M (2006). FDTD-based time reversal for microwave breast cancer detection-localization in three dimensions. IEEE Trans. Microwave Theory Tech. 54:1921–1927.

65. Kriege M, Brekelmans CT, Boetes C (2004). Efficacy of MRI and mammography for breast cancer screening in women with a familial or genetic predisposition. N Engl J Med .351:427–500.

66. Kubota S, Xia Xiao, Sasaki N, Kimoto K, Moriyama W , Kikkawa T (2008). Experimental Confocal Imaging for Breast Cancer Detection Using Silicon on-Chip UWB Micro antenna Array. Antennas and Propagation Society International Symposium 1-4.

67. Lazebnik. M, McCartney. L, Popovic. D, Watkins C. B,. Lindstrom M. J, Harter J, Sewall S, Magliocco A, Booske J. H, Okoniewski M, Hagness S. C (2007). A large-scale study of the ultrawideband microwave dielectric properties of normal breast tissue obtained from reduction surgeries. Phys. Med. Biol. 52:2637-2656.

68. Leach MO, Boggis CR, Dixon AK (2006). Screening with magnetic imaging and mammography of a UK population at high familial risk of breast cancer: A prospective multicenter cohort study (MARIBS). Lancet. 365:1769–1778.

69. Lehman C. D, Gatsonis C, Kuhl C. K, Hendrick R. E (2007). MRI evaluation of the contra lateral breast in women with recently diagnosed breast cancer. New Eng. J. Med 356:1295–1303.

70. Li X, Davis S. K , Hagness S. C , vander Weide D. W ,van Veen B. D (2004). Microwave imaging via space-time beamforming: Experimental investigation of tumor detection in multi-layer breast Phantoms. IEEE Transactions on Microwave Theory and Techniques. 52:1856-1865.

71. Li, X., Hagness S. C. (2001). A confocal microwave imaging algorithm for breast cancer detection. IEEE Microwave and Wireless Components Letters. 11(3):130-132.

72. Liberman L, Feng TL, Dershaw DD, Morris EA, Abramson AF (1998). US guided core breast biopsy: use and cost effectiveness. Radiology. 208:717–723.

73. Lin SP, Brown JJ (2007). MR contrast agents: physical and pharmacologic basics. J Magn Reson Imaging. 25:884–899.

74. Mandelson MT, Oestreicher N, Porter PL (2000). Breast density as a predictor of mammographic detection: comparison of interval- and screen detected cancers. J Natl Cancer Inst 92:1081–1087.

75. Mariya Lazebnik, Susan C. Hagness, John H. Booske (2008).Dielectric-Properties Contrast Enhancement for Microwave Breast Cancer Detection: Numerical Investigations of Microbubble Contrast Agents. XXIX General Assembly Int. Union Radio Sci. (URSI).Chicago. IL.

76. Maskooki. A, Gunawan E, Soh C. B, Low K. S (2009). Frequency Domain Skin Artifact Removal Method For Ultra-Wideband Breast Cancer Detection. Progress In Electromagnetics Research. PIER 98. 299-314.

77. Meaney P. M, Paulsen K. D, Chang J. T, Fanning M. W, Hartov (1999) .A Non active antenna compensation for fixed-array microwave imaging: art II - Imaging results. IEEE Trans. Medical Imaging. 18:508-518.

78. Nass S. L, Henderson I. C, Lashof J. C (2001). Mammography and Beyond: Developing Technologies for the Early Detection of Breast Cancer. Washington. DC: Institute of Medicine. National Academy Press.

79. O'Halloran, M., M. Glavin, E. Jones (2009). Effects of fibroglandular tissue distribution on data-independent beamforming algorithms. Progress In Electromagnetics Research. 97:141-158.

80. Parker SH, Jobe WE, Dennis MA (1993). US guided automated large core breast biopsy. Radiology. 187:507–511.

81. Pisano ED, Gastonis C, Hendrick E (2005).Diagnostic performance of digital versus film mammography for breast cancer screening. N Engl J Med 353:1–11.

82. Rangayyan, R. M., El-Faramawy N. M, Desautels J. E. L., Alim O. A. (1997). Measures of acutance and shape for classiffication of breast tumors. IEEE T-MI. 16(6): 799-810.

83. Salvador, S. M, Vecchi G (2009). Experimental tests of microwave breast cancer detection on phantoms. IEEE Transactions on Antennas and Propagation 57: 1705-1712.

84. Saslow D, Boetes C, Burke W (2007). American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography.CA Cancer J Clin. 57:75–89.

85. Seidman H, Stellman SD, Mushinski MH (1982). A different perspective on breast cancer risk factors: some implications of the non attributable risk. CA Cancer J Clin 32:301–313.

86. Shapiro S, Venet W, Strax P, Venet L,Roeser R (1982). Ten to 14-year effect of screening on breast cancer mortality. J Natl Cancer Inst 69:349–355.

87. Sill J. M, Fear E. C (2005). Tissue sensing adaptive radar for breast cancer detection — Experimental investigation of simple tumor models. IEEE Transactions on Microwave Theory and techniques. 53:3312-3319.

88. Siti Hasmah binti Mohd Salleh, Mohd Azlishah Othman, Nadhirah Ali, Microwave imaging technique using UWB signal for breast cancer detection, ARPN Journal of Engineering and Applied Sciences, pp723-727, Vol. 10, NO. 2, 2015

89. Southern Cross Health care Group, Breast Cancer (Symptoms, diagnosis, treatment) (2006), Retrieved from http://www.southerncross.co.nz/AboutTheGroup/HealthResources/MedicalLibrary/tabid/178/vw/1/ItemID/41/Breast-Cancer-Symptoms-diagnosis-treatment.aspx.]. (Last access date: 15 October 2011).

90. Staren E. D, O'Neill T. P (1998). Breast ultrasound. Surg. Clin. North Amer 78:219–235.

91. Tavassolian.N, Nikolaou S, Tentzeris, M.M A (2007). Flexible UWB Elliptical Slot Antenna with a Tuning Uneven U-shape Stub on LCP for Microwave Tumor Detection. Asia-Pasific Microwave (APMC 2007). 1–4.

92. Tonny Rubaek,Andreas Fhager, Peter Damsgaard Jensen, Johan Jacob Mohr,Mikael Persson (2011). Microwave Imaging for Breast Cancer Detection: Comparison of Tomographic Imaging Algorithms using Single-Frequency and Time-Domain Data. Union Radio Scientifique Internationale.

93. Viehweg P, Paprosch I, Strassinopoulou M , Heywang Kobrunner S. H (1998). Contrast enhanced magnetic resonance imaging of the breast: Interpretation guidelines. Top.Magn. Reson. Imag 9:17–43.

94. Wee Chang Khor, Aslina Abu Bakar, Bialkowski Marek E (2009). Investigations into Breast Cancer Detection using Ultra Wide Band Microwave Radar Technique. Microwave Conference, APMC.

95. Wenkel E, Heckmann M, Heinrich M: Automated breast ultra-sound (2008). Lesion detection and BI-RADS classification– a pilot study. Rofo. 9: 804–808.

96. Wenyi Shao, Adams. R.S (2011). UWB microwave imaging for early breast cancer detection: A novel confocal imaging algorithm. Antennas and Propagation (APSURSI). 707 – 709.

97. Winters D. W, Shea J. D, Kosmas P, Van Veen B. D, Hagness S. C (2009). Three-dimensional microwave breast imaging: dispersive dielectric properties estimation using patient-speciûc basis functions. IEEE Trans. Med. Imag. 28: 969–981.

98. Xia XiaoI, Xu Liu, Bingyu Liu (2009). Study on Microwave Imaging for the Early Breast Cancer Detection by FDTD with PML Boundary Condition. International Conference on Future Biomedical Information Engineering. China.

99. Xie Y, Guo B, Li J, Stoica P (2006). Novel multistatic adaptive microwave imaging methods for early breast cancer detection. EURASIP J. Appl. Si. P. 2006(91961):1-13.

100. Yifan Chen ,Erry Gunawan, Yongmin Kim, Kaysoon Low, CheongboonSoh (2006). UWB Microwave Imaging for Breast Cancer Detection: Tumor/Clutter Identification Using a Time of Arrival Data Fusion Method. IEEE Antennas and Propagation Society International Symposium.

101. Yusoff N I M, Khatun S, AlShehri S.A (2009). Characterization of Absorption Loss for UWB Body Tissue Propagation Model. Proceedings of the 2009 IEEE 9th Malaysia International Conference. Malaysia.

102. Zhuge X , Hajian M , Yarovoy A.G, Ligthart L.P (2007). Ultra-Wideband Imaging for Detection of Early Stage Breast Cancer. Proceedings of the 4th European Radar Conference. Munich Germany.