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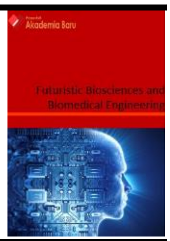

Improved Confocal Microwave Imaging Algorithm for Tumor Detection

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ABSTRACT

The confocal microwave imaging technique is one of the derivatives in UWB radar imaging. An antenna array is utilized to transmit the signals for the whole imaging area of interest for useful data information. MATLAB software is used to process the data obtained using confocal microwave imaging algorithm in generating images. As for upgraded delay and sum (uDAS) algorithm, additional filtering steps are included in the original delay and sum algorithm to achieve higher image resolution and more accuracy in detection. An analysis of the localization error and signal to noise ratio (SNR) are done in evaluating the effectiveness of the upgraded confocal microwave imaging algorithm. Images between original algorithm and upgraded one are compared in term of resolution and accuracy. The uDAS images demonstrated clearer and sharper images and areas with higher pixel intensity. Tumor in the image is represented by the highest color intensity (reddish orange spot), due to the strongest scattering region indicating the tumor existence in the human head phantom.

Keywords:
Confocal imaging, algorithm, tumor detection

1. Introduction

Previously, a lot of researchers are interested in the related research of microwave imaging. Most of the researches are concentrating more on breast imaging. Recently, the interest of utilizing microwave imaging is gaining in brain abnormalities detection of brain abnormalities, especially for tumor detection. Tissue structures are imaged based on differences in their dielectric properties in microwave imaging. Permittivity, conductivity or magnetic permeability of any object is obtained from measuring scattering signals originated from the object [1].

The capability of propagating ultra-wideband pulse and the possibility of detecting transmitted and reflected signals are the main concern in microwave imaging. Things become interesting when

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the regulations reflected on medical imaging systems decided on the utilization frequency band of 3.1 to 10.6 GHz and an emitted isotropically radiated power of -41.3dBm are introduced.

In radar-based brain microwave imaging, UWB antenna transmits a short pulse into the human brain phantom and receives back the scattering signals as the propagation approach. The process is repeated for different areas to cover at least one whole side of the head phantom in ensuring no miss-scan area left behind. The tumor would lead to high scattering signals and that kind of reflection could suggest the existence and placement of the tumor [2].

According to [3], a very narrow pulse is transmitted from a UWB antenna to penetrate the body structure in the UWB imaging system. Reflection, scattering, and absorption take place at the interference of various tissues as the pulse propagate. The same goes for the tumor where the scatter signals produced when the pulse encounter small size tissue of the tumor. A UWB antenna or array of UWB antenna can act as the reflected and scattered signal receiver for mapping the different layer of the human body. The UWB antenna should be associated with high resolution and dynamic range, planar, compact in size and directive with high radiation efficiency and distortionless pulse transmission or reception for efficient imaging system [3].

The confocal microwave imaging (CMI) technique is one of the derivatives in UWB radar imaging. It can be categorized into monostatic and multi-static techniques. An antenna array is utilized to transmit the signals for the whole imaging area of interest for multistatic meanwhile transmit the signals toward the whole imaging area by moving an antenna in a different area for monostatic technique. On the other hand, for bi-static, it involves two different antennas act as the transmitter and another one as the receiver.

Beamforming algorithm is used to analyze backscattered or reflected signals captured by the antennas known as confocal microwave imaging algorithm, delay-and-sum (DAS) imaging algorithm or time-shift-and-sum beamforming. The algorithm is widely used in ultra-wideband microwave imaging especially for the breast imaging introduced by [4, 5] based on the well established in ground penetrating radars. Another algorithm using FDTD was presented in [6] and experimentally demonstrated the reliability study done by [7].

Until now, several modifications have been applied to the standard DAS to suit with current advanced technology in improving the image quality and detection accuracy. Some of these are the delay multiply and sum (DMAS) algorithm proposed by [8], improved delay and sum (IDAS) algorithm proposed by [9] and enhanced delay and sum (EDAS) algorithm [10]. This thesis emphasizes the efficiency of the proposed upgraded version of the algorithm for brain tumor detection in a human head.

2. Methodology

Figure 1 illustrated the measurement setup for brain tumor detection using microwave radar imaging technique

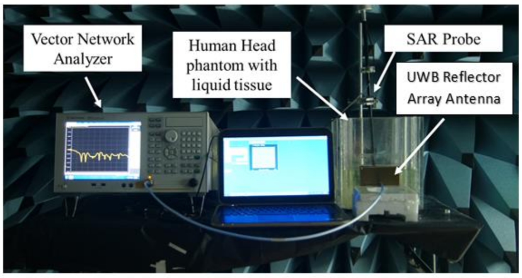


Fig. 1. Measurement setup for microwave imaging

It consists of VNA, UWB sensor and human head phantom with the presence of a tumor. The measurements take place in the anechoic chamber to eliminate the unwanted signal that could interfere with the desired signal throughout the whole process of obtaining the data.

The UWB sensor is perfectly placed 10 mm away from the multilayer human head phantom to have maximum signal penetration. The sensor radiated the signal towards human head phantom with two different conditions which are one with tumor present meanwhile another one is without the tumor present to obtain the difference of the scattering parameter value. The sensor radiated the signal towards nine different areas to cover the whole one-sided area of the phantom as shown in Figure 2 where the tumor located at position 5. Both data with and without tumor are subtracted from each other and the difference obtained is then processed in order to produce the desired image. MATLAB software is used to process the data obtained using confocal microwave imaging algorithm.

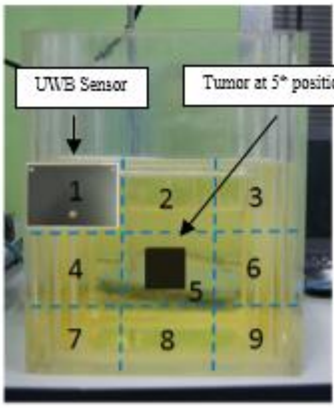
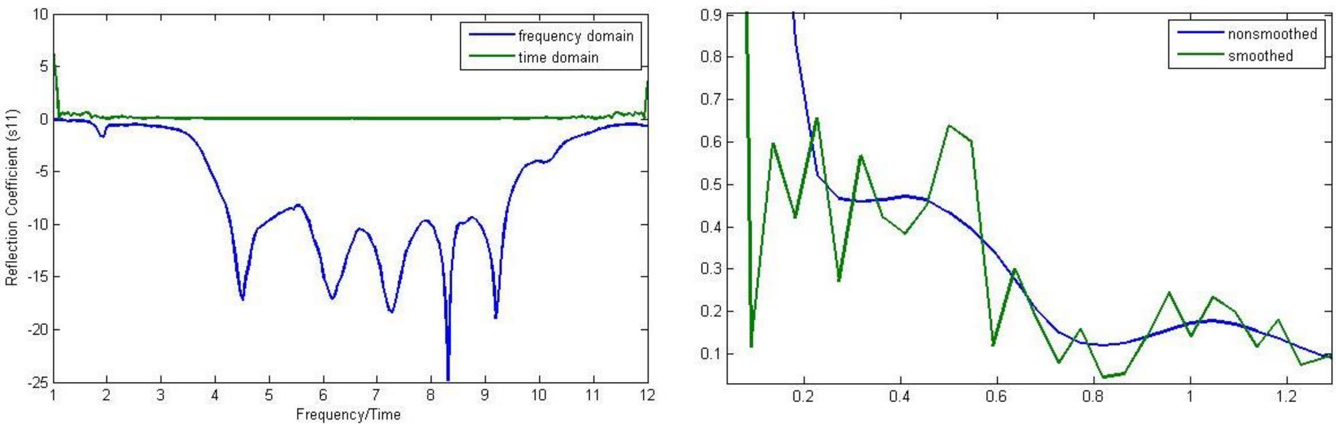


Fig. 2. Scanning Area for Human Head Phantom

Figure 3 shows the graph for frequency domain and time domain for one same cycle of signals. Frequency domain represented by negative data values meanwhile time domain recorded positive data value. The data in the frequency domain need to be transformed to the time domain since confocal algorithm depends on round trip time for image generation [11].



(a) (b)

Fig. 3. (a) Frequency domain and time domain for one same cycle of signals, (b) Smooth signal of time domain using IFFT

For the algorithm, averaging and interpolation step has been applied in order to have a better and clearer image. Averaging functioned to eliminate the effects of clutters originated from dominating reflections of the environment, equipment, and the antenna. On the other hand, theoretically, interpolation is a method of constructing new data points within the range of a discrete set of known data points. Meanwhile specifically for imaging, interpolation assists in filling the empty element between the adjacent pixels by assuming based on that particular adjacent pixels value[12]. Figure 4 shows the flow chart of the UWB confocal algorithm for data generation and image construction.

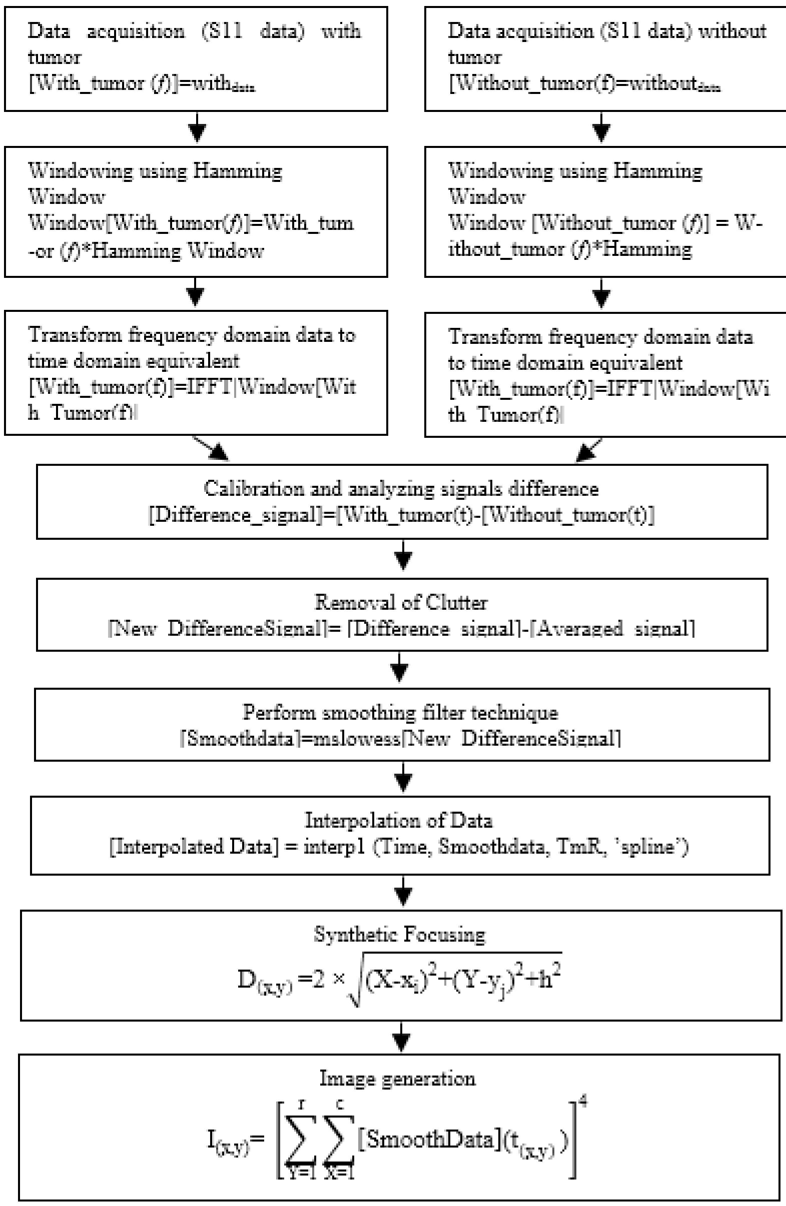
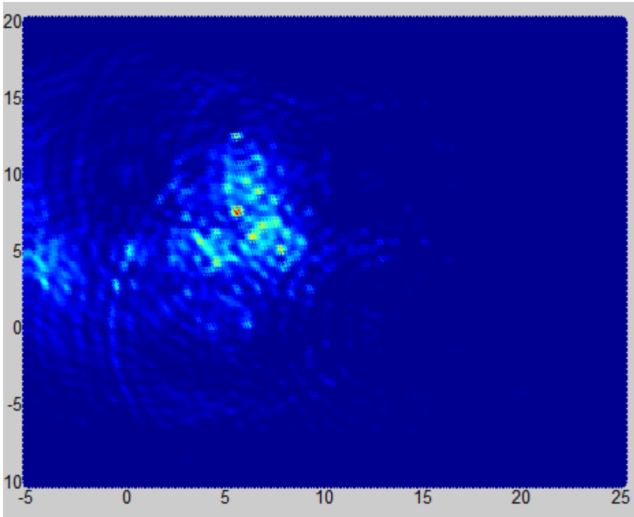


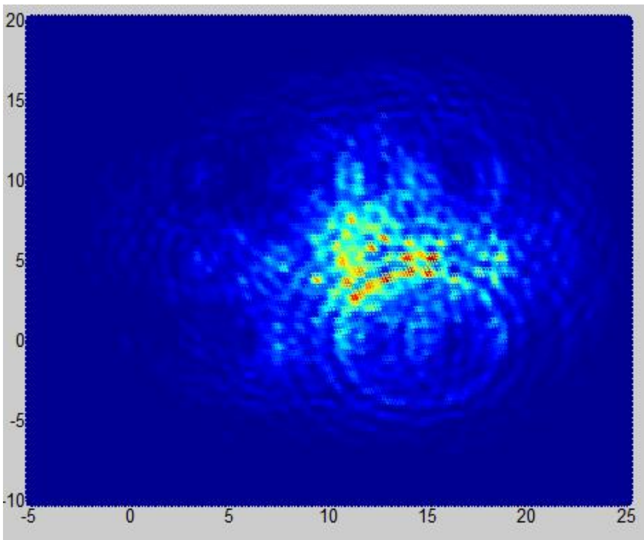
Fig. 4. UWB Confocal Microwave Imaging Algorithm for image construction

3. Results

As for UWB confocal algorithm, averaging and interpolation steps are included in the algorithm to achieve better image clarity. Averaging eliminates the effects of clutters originated from reflections from the environment, equipment, and the antenna. Meanwhile, interpolation constructs new data points within the range from a discrete set of known data points. It assists the filling of the empty elements in between the adjacent pixels [13]. Figure 5 shows the effects of interpolation and averaging algorithm during the process of producing the image.



(a)



(b)

Fig. 5. (a) Interpolated image and (b) averaged image.

Figure 6 shows the images processed using the confocal algorithm without tumor and with the tumor present, respectively. The images demonstrated the efficiency of the improved delay and sum algorithm with clearer and sharper images and areas with higher pixel intensity. Tumor in the image is represented by the highest color intensity (reddish orange spot), resulting from the strongest scattering region [14]. This corresponds to tumor existence in the human head phantom.

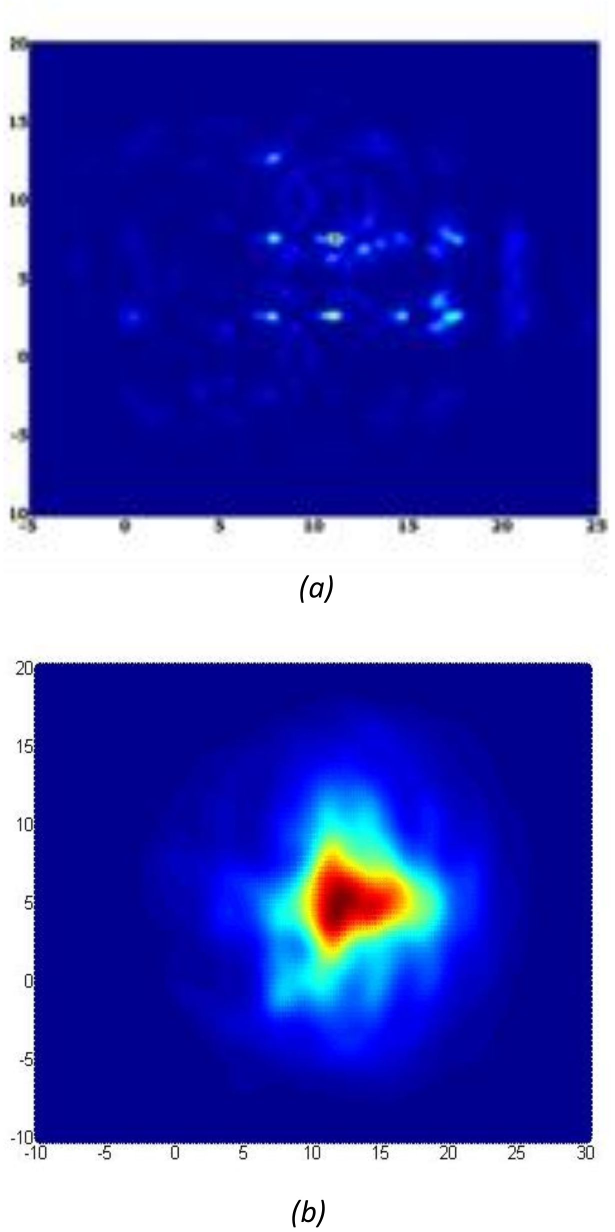


Fig. 6. Final image; (a) without tumor (b) with tumor

4. Conclusions

Improved confocal microwave imaging algorithm successfully enhanced the generated image of detected cancer. The resulted images demonstrated a clearer and sharper outline of the tumor itself. The improved algorithm assisted by additional steps of averaging and interpolation in the overall confocal microwave imaging algorithm. Averaging specifically eliminates the effects of clutters originated from reflections from the environment, equipment, and the antenna while interpolation constructs new data points within the range from a discrete set of known data points for assisting the filling of the empty elements in between the adjacent pixels. Proposed future work includes investigating this system on the larger experimental region and with the presence of multiple tumors.

References

[1] Yob, Rashidah Che, and Norhudah Seman. "Wideband multi-port reflectometer in microstrip planar technology for microwave imaging application." In *2012 IEEE Asia-Pacific Conference on Applied Electromagnetics (APACE)*, pp. 377-382. IEEE, 2012.

[2] Chew, Kim Mey, Rubita Sudirman, Nasrul Humaimi Mahmood, Norhudah Seman, and Ching Yee Yong. "Human brain microwave imaging signal processing: Frequency domain (s-parameters) to time domain conversion." *Engineering* 5, no. 05 (2013): 31.

[3] Abbosh, Amin M. "Directive antenna for ultrawideband medical imaging systems." *International Journal of Antennas and Propagation* 2008 (2008).

[4] Hagness, Susan C., Allen Taflove, and Jack E. Bridges. "Two-dimensional FDTD analysis of a pulsed microwave confocal system for breast cancer detection: Fixed-focus and antenna-array sensors." *IEEE Transactions on Biomedical Engineering*45, no. 12 (1998): 1470-1479.

[5] Hagness, Susan C., Allen Taflove, and Jack E. Bridges. "Three-dimensional FDTD analysis of a pulsed microwave confocal system for breast cancer detection: Design of an antenna-array element." *IEEE Transactions on Antennas and Propagation* 47, no. 5 (1999): 783-791.

[6] Li, Xu, and Susan C. Hagness. "A confocal microwave imaging algorithm for breast cancer detection." *IEEE Microwave and wireless components letters* 11, no. 3 (2001): 130-132.

[7] Fear, Elise C., J. Bourqui, C. Curtis, D. Mew, B. Docktor, and C. Romano. "Microwave breast imaging with a monostatic radar-based system: A study of application to patients." *IEEE transactions on microwave theory and techniques* 61, no. 5 (2013): 2119-2128.

[8] Lim, Hooi Been, Nguyen Thi Tuyet Nhung, Er-Ping Li, and Nguyen Duc Thang. "Confocal microwave imaging for breast cancer detection: Delay-multiply-and-sum image reconstruction algorithm." *IEEE Transactions on Biomedical Engineering* 55, no. 6 (2008): 1697-1704.

[9] Klemm, M., I. J. Craddock, J. A. Leendertz, A. Preece, and R. Benjamin. "Improved delay-and-sum beamforming algorithm for breast cancer detection." *International Journal of Antennas and Propagation* 2008 (2008).

[10] Tiang, Sew S., Mohammed Sadoon, Tareq F. Zanoon, Mohd F. Ain, and Mohd Z. Abdullah. "Radar sensing featuring biconical antenna and enhanced delay and sum algorithm for early stage breast cancer detection." *Progress In Electromagnetics Research B* 46 (2013): 299-317.

[11] Camacho, Luis M., and Saibun Tjuatja. "FDTD simulation of microwave scattering from a lung tumor." In *2005 IEEE Antennas and Propagation Society International Symposium*, vol. 3, pp. 815-818. IEEE, 2005.

[12] Abdul-Sattar, Zubaida. "Experimental analysis on effectiveness of confocal algorithm for radar based breast cancer detection." PhD diss., Durham University, 2012.

[13] Mathworks.com. 'Filtering and Smoothing Data - MATLAB & Simulink' Retrieved 15 May, 2015, from http://www.mathworks.com/help/curvefit/smoothing-data.html.

[14] Meaney, Paul M., Margaret W. Fanning, Dun Li, Steven P. Poplack, and Keith D. Paulsen. "A clinical prototype for active microwave imaging of the breast." *IEEE Transactions on Microwave Theory and Techniques* 48, no. 11 (2000): 1841-1853.