Smart Machine Learning Based Breast Cancer Tumor Detection using Microwave Textile Based Antenna sensors

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Abstract (300 word limit)

Statement of the problem: This talk aims to provide an insightful idea about a new comfortable wearable system using fully textile antenna-based sensors to develop a microwave breast imaging system [1-2]. The proposed system will help women to receive regular breast cancer screening safely specifically young women with dense breast. Breast cancer is a leading cause of death among females according to Word Health Organization (WHO). The proposed sensor is compact and fully made of textiles so that it fits comfortably on the breast with dimensions 24× 45× 0.17 mm^3 on a cotton substrate [1-2]. Two innovative wearable antennas are the main pillars for the intended systems. Microwave breast imaging has the potential to replace or act as an additional tool to the standard X-ray mammography for detecting breast cancer. The proposed antenna sensor is fed with a coplanar waveguide feed for easy integration with other systems. The proposed sensor acquires low specific absorption rate (SAR) of 0.55 W/Kg and 0.25 W/Kg at 1g and 10 g, respectively at 25 dBm power level over the operating band [3-4]. Furthermore, the proposed system utilizes machine-learning algorithms (MLA) to differentiate between malignant tumor or benign breast tissues. Simulation examples have been recorded to verify and validate machine-learning algorithms in detecting tumors at different sizes of 10 mm and 20 mm, respectively. The classification accuracy reached 100% on the tested dataset when considering $|S_{21}|$ parameter features [5]. The proposed system is visioned as "Smart Bra" that is capable to provide an easy interface for women who require continuous breast monitoring at the comfort of their homes.

Methodology & theoretical orientation: The proposed detection and monitoring system for Breast is visioned in Figure below as "Smart Bra". It proposes a new comfortable wearable system that will help women to receive regular breast cancer screening safely specifically young women with dense breast using Microwave. The prospective system is planned to use textiles for fabricating antenna-based sensors. Microwave breast imaging has the potential to replace or act as an additional tool to the standard X-ray mammography for detecting breast cancer.

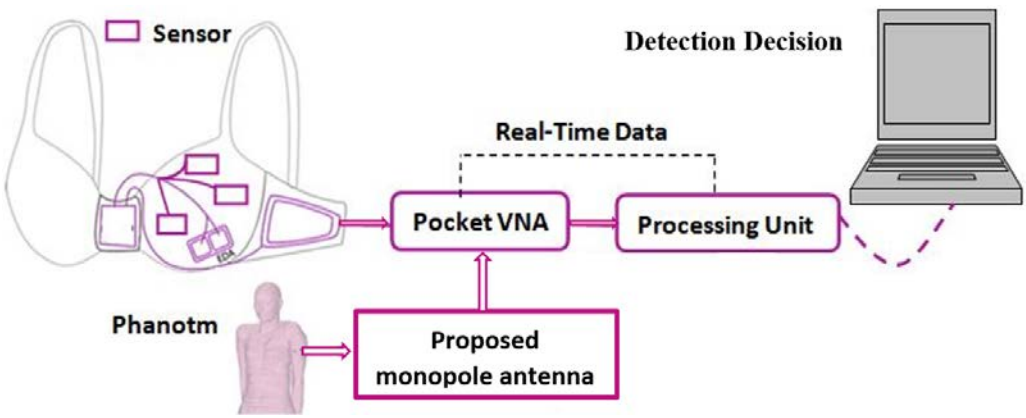


Figure 1. *The proposed breast cancer detection system as "Smart Bra".*

Conclusion: The study in this paper develops compact and ultra-wideband flexible sensors using two technologies. The first technology used is flexible Roger substrate while the second is Conductive fabric implemented on cotton substrate. The performance of the proposed antenna-based sensor using the two technologies are recorded and compared. The simulations validate similar performance of the proposed antenna-based sensor antenna using conductor fabric compared to flexible Roger substrate especially at frequency less than 7 GHz. Both types of conductors reveal similar operation in terms of reflection coefficient and impedance matching. The wearable textile antenna sensors acquire UWB performance with extended bandwidth from 1.6 GHz up to 10 GHz at |S11| ≤-6 dB and acceptable antenna average gain about 3 dBi. The gain using flexible conductor substrate is higher than textile antenna by 3 dBi in average over the operating antenna band. Sensors fabricated with conductive fabric shows better performance compared to those with flexible Roger substrate sheet as it provides lower substrate loss and better fitting with women breast where no air in-between. On the other side, Sensor fabricated using flexible copper surface interacts with human sweat and could be subjected to rusting over time. Thus, conductive fabrics are more favored for fabricating wearable sensors in this study. Moreover, Machine learning algorithms have been developed and used to classify different scanning states using recorded S-parameters. The simulation examples also verify the capabilities of machine learning algorithms in breast cancer tumor classification. A comparison between different classification techniques has been carried out for different datasets of different tumor sizes. These examples verify the effectiveness of S_{21} parameter in improving the classification accuracy of "CatBoost" from 69% to 100% for 20mm tumor size. It also shown that, the classification accuracy is influenced by the tumor size where the accuracy improved from 83% to 100% between 10 mm and 20 mm tumor sizes.

References

1. Elsheikh, D.; Eldamak, A. R. Microwave Textile Antenna sensors for Breast Cancer Detection. In 2021 38th National Radio Science Conference (NRSC); 2021; Vol. 1, pp 288–294. https://doi.org/10.1109/NRSC52299.2021.9509829.
2. Elsheakh, D.M.N., Alsherif, S.A. and Eldamak, A.R., Textile Monopole Antenna sensors for Breast Cancer Detection,2022, Preprint, https://doi.org/10.21203/rs.3.rs-1074337/v1
3. Kwon, S.; Lee, S. Recent Advances in Microwave Imaging for Breast Cancer Detection. International Journal of Biomedical Imaging, 2016, 1–26. https://doi.org/10.1155/2016/5054912.
4. Rahayu, Y.; Waruwu, I. Early detection of breast cancer using ultra-wide band slot antenna. SINERGI 2019, 23 (2), 115. https://doi.org/10.22441/sinergi.2019.2.004.
5. D. N. Elsheakh; Rawda Mohamed; O. M. Fahmy; Khaled Ezzat; A. R. Eldamak, "Complete Breast Cancer Detection and Monitoring System by Using Microwave Textile Based Antenna Sensors", MDPI Biosensors 2023, 13, 87, https://doi.org/10.3390/bios13010087.

Biography

Dr. Omar Fahmy is currently an associate professor at Computer Engineering Dept., School of Engineering, Badr University in Cairo. In 2020, Dr. Omar has become an IEEE senior member. Since 2019, he has been working as a senior researcher at Electrical Engineering Dept., South Ural State University in Russia. In 2015, he had a short-term postdoctoral researcher in Electrical Engineering Department, University College of London in the field of video processing and micro-movement magnification. In 2013, he had a postdoctoral research fellow fully funded from ERASMUM MUNDUS Green IT- EU at Universidad de Vigo, Spain. His research was in image forensics and its applications. His research interests are in image processing, image forensics, computer vision, machine learning and their related areas. His research work results in 35 publications in international peer-reviewed journals and IEEE conferences in the field of computer vision, machine learning and image processing. He is a member in many reviewing committees of peer-reviewed journals and conference. Dr. Omar had received his PhD, Master's. and Bachelor's degrees in Communication Engineering from Assiut University in 2012, 2008, and 2006 respectively.

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