Passive AI Microwave Radiometry for Breast and Ovarian Cancer

Igor Goryanin[1,2], Christoforos Galazis[3], Chingis Mustafin[2], Arran Turnbull[1], Mike Dixon[1], Srinjoy Mitra[1], Michal Wiercigroch[1] , Bob Damms[2]
Sergey Vesnin[2]

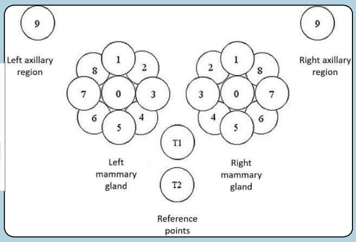
[1] University of Edinburgh, Edinburgh, United Kingdom
[2] MMWR Ltd, United Kingdom
[3] Department of Computing, Imperial College London, London, United Kingdom

Background

Passive microwave radiometry (MWR) has a long history. Recen advances in engineering and AI allowed to used MWR for diagnostics if different pathologies.

Early and accurate detection of breast cancer is critical for improving treatment outcomes and patient survival rates. Traditional screening methods such as mammography and ultrasound, while effective in many cases, often fall short—particularly in patients with dense breast tissue—due to limitations in sensitivity and the need for ionizing radiation. In response, innovative diagnostic modalities like passive microwave radiometry (MWR) are emerging as viable alternatives. MWR is a non-invasive technique that passively measures the natural microwave emissions emanating from human tissues [1]. Cancerous tissues, which exhibit an increased metabolic rate, produce elevated levels of microwave radiation compared to their healthy counterparts [2]. This phenomenon enables MWR to effectively differentiate between malignant and benign tissues, potentially leading to:

MMWR2020 dual-band point-of care device



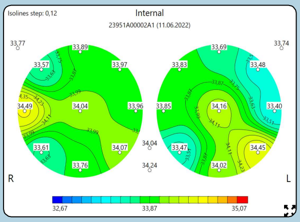
Points Measured for Diagnosis of Breast Cancer

Methodology

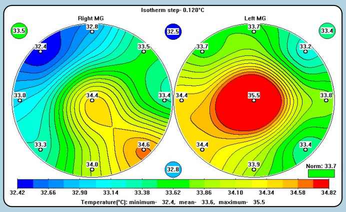
In our studies, we employed the MWR2020 dual-band point-of-care device developed by MMWR Ltd. This advanced device simultaneously captures both infrared emissions (indicating skin surface temperature) and microwave emissions (reflecting internal tissue temperature) at a frequency range between 3.5 and 4.2 GHz. The device penetrates tissues to a depth of 3–7 cm and achieves a measurement accuracy of ±0.2°C.

For each patient examination, temperatures were recorded at 22 selected anatomical locations. These included eight points arranged around each nipple, one point directly at the nipple, the left and right axillary regions, and two additional points beneath the chest. As a result, a total of 44 readings—comprising both skin and internal temperature measurements—were acquired per case [3]. These data points served as input features for our deep neural models.

Our research is supported by a robust dataset collected from clinics worldwide. Out of 30,000 patient records, a rigorously cleaned subset of 4,932 cases was analysed, including 548 cases diagnosed with either malignant or benign tumors. Machine learning and deep neural network models were trained on this extensive clinically verified dataset to distinguish between healthy, benign, and malignant states based on microwave radiometry readings. This training encompassed temperature asymmetry features, morphological patterns, and other clinical parameters. The Neural network models are continuously updated via a secure cloud infrastructure, improving diagnostic accuracy as more real-world data are incorporated [6].



Example of Healthy Internal Breast Temperatures, the green colour indicates normal state and the blue colour indicates deep temperature decrease.



Example of Cancerous Breast Internal Temperatures

Some of the key advantages of the passive MWR approach include:

- **Non-Invasiveness:** No exposure to ionizing radiation or need for tissue compression.
- **Deep Tissue Sensitivity:** Effective detection up to 60 mm beneath the skin, far surpassing the 5 mm depth of traditional infrared thermography.
- **Rapid and Cost-Effective Screening:** Minimal operational costs and quick measurement times facilitate frequent monitoring.
- **Enhanced Diagnostic Precision**: Integration with AI and additional biomarkers such as microRNA (miRNA) expression further refines the sensitivity and specificity of cancer detection.

References

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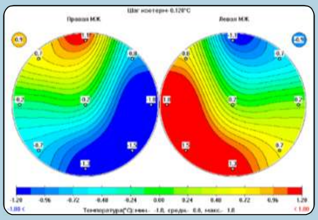
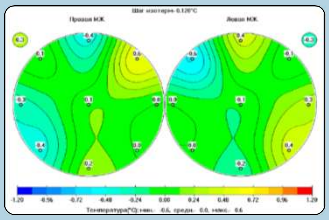
Results

Using our dataset and novel deep neural network methods, we achieved a breast cancer prediction accuracy of 0.95 ± 0.003. Breast cancer prevention is a critical health issue for women worldwide. In this study, we compared conventional breast cancer screening exams, such as mammography and ultrasound, with novel approaches using passive microwave radiometry (MWR) and microRNA (miRNA) analysis. While mammography screening dynamics require 3-6 months, MWR provided predictions in a matter of weeks or even days. Moreover, MWR has the potential to be complemented with miRNA diagnostics to further improve its predictive accuracy. These novel techniques can be used alone or in conjunction with more established methods to enhance early breast cancer diagnosis [4].

The proposed MWR of the mammary glands allows for the non-invasive, painless and safe determination of latent subcapsular inflammation of the mammary glands after endoprosthesis procedures, which is usually not accompanied by complaints and clinical manifestations, which allows for conservative treatment, thereby preventing the development of capsular contracture and choosing adequate and timely treatment tactics, which allows to avoid repeated surgeries [5].

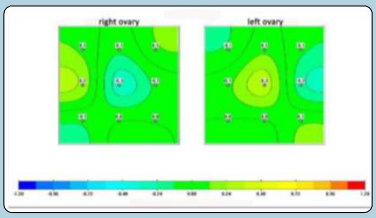


MWR fields of mammary glands after endoprosthesis. Latent subcapsular inflammation of breast tissue, a tendency to form fibrosis.

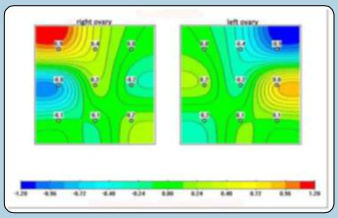


MWR fields of the mammary glands after 21 days of complex conservative treatment.

Furthermore, MWR has been used to address the challenge of late-stage ovarian cancer diagnosis, which often carries a poor prognosis due to the lack of clear diagnostic algorithms. Transabdominal MWR temperature measurements were taken at nine symmetrical points of the iliac region on both sides. In ovarian cancer diagnostics, the application of transabdominal MWR demonstrated an overall diagnostic accuracy of 90%. Temperature deviations beyond 0.5°C in the iliac regions served as a reliable indicator of neoplastic activity, with more pronounced hyperthermia (>1.1°C) correlating with a higher risk of malignancy.



Example of healthy Ovarian Temperatures (There are no signs of focal hyperthermia.)



Example of Unhealthy Ovarian Temperatures (Signs of hyperthermia in the projection of the ovaries.)

Conclusion and Future Directions

Passive microwave radiometry represents a significant advancement in the non-invasive diagnosis and monitoring of breast cancer. The MWR2020 device, which is registered as a CE and MHRA Class I device, has proven its clinical utility by delivering rapid and highly accurate diagnostic predictions. Our research demonstrates that MWR not only rivals traditional imaging techniques in sensitivity but also offers several unique advantages: it avoids harmful ionizing radiation, minimizes patient discomfort, and is easily deployable across various clinical environments.

Looking ahead, we plan to enhance our AI-MWR system by further integrating it with additional clinical biomarkers and refining our neural network algorithms. Other objective is the development of a handheld Bluetooth sensor, and 18-channel microwave radiometer for continuous monitoring, which includes innovations such as the SmartBra for breast diagnostics and SmartBriefs for ovarian cancer. Moreover, efforts are underway to miniaturise the device—targeting a form factor of 40 mm in diameter and 12 mm in height with an improved accuracy of 0.1°C—which could open avenues for wearable applications. Future clinical studies will focus on validating these advancements to secure Class II certification, expanding the use of MWR in treatment monitoring, hyperthermia treatment control, and a wide range of other diagnostic applications.

Early of Prototype Miniature MWR device

Hand-held battery powered sensor under development

Smart Bra

Smart Briefs. Artistic view.
Multi-antennae one channel radiometer

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