A Smart Textile System for The Early Detection of Breast Cancer Using Electrical Impedance Tomography

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Incidences of breast cancer in the UK are projected to increase by 13.1% (2023-2040), coupled with COVID-19's impact on screening services, this presents an urgent healthcare challenge. Early detection significantly improves survival rates for this type of cancer, current screening methods face limitations including radiation exposure, high costs, and restricted accessibility. This research addresses these challenges by developing an innovative smart textile system that integrates Electrical Impedance Tomography (EIT) technology into underwear in the form of a bra for continuous breast cancer monitoring.

Our approach utilises EIT's ability to detect variations in tissue electrical properties by applying small electrical currents and measuring the resulting voltage patterns. Malignant breast tissues exhibit notably different dielectric characteristics compared to healthy tissue in a frequency range of 1 kHz to 1 GHz. The system comprises three key innovations: (1) A high-resolution flexible integrated circuit with 16 electrodes arranged in concentric circles, (2) Biocompatible printed electrodes integrated into textile, and (3) Wireless data transmission for real-time monitoring.

Through both computational and experimental validation, we have demonstrated the system's effectiveness. Initial simulation provided proof of concept, showing the theoretical capability to distinguish between healthy breast tissue and tumours as small as 10mm (corresponding to Stage 1 breast cancer) in the presence of a 1mA electric field. Laboratory testing with phantom models confirmed these findings, demonstrating the system's practical capability to detect inclusions as small as 10mm, with detection accuracy improving significantly for larger sizes (30-40mm). Statistical analysis shows strong correlation between detection probability and inclusion characteristics ($p=3.10e-287$ (< 0.05)). The voltage patterns obtained from experimental measurements showed strong correlation with simulation data, validating our theoretical framework and experimental setup.

This research represents a significant step toward personalised and in the home breast cancer screening, potentially offering a radiation-free, cost-effective solution that could complement existing screening methods such as Mammography and MRI. The technology's wearable nature enables continuous monitoring, particularly beneficial for high-risk patients and addressing post-COVID screening backlogs.

Keywords: Breast Cancer Detection, Electrical Impedance Tomography, Smart Textiles, Wearable Technology.