Exploring the Potential of Radar Technology for Tumour Detection

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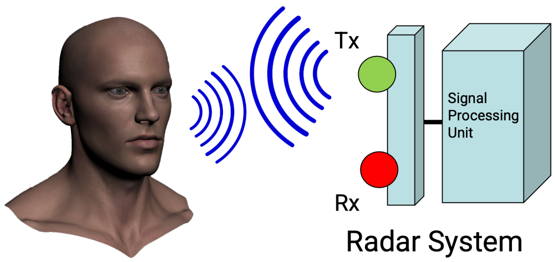
Abstract

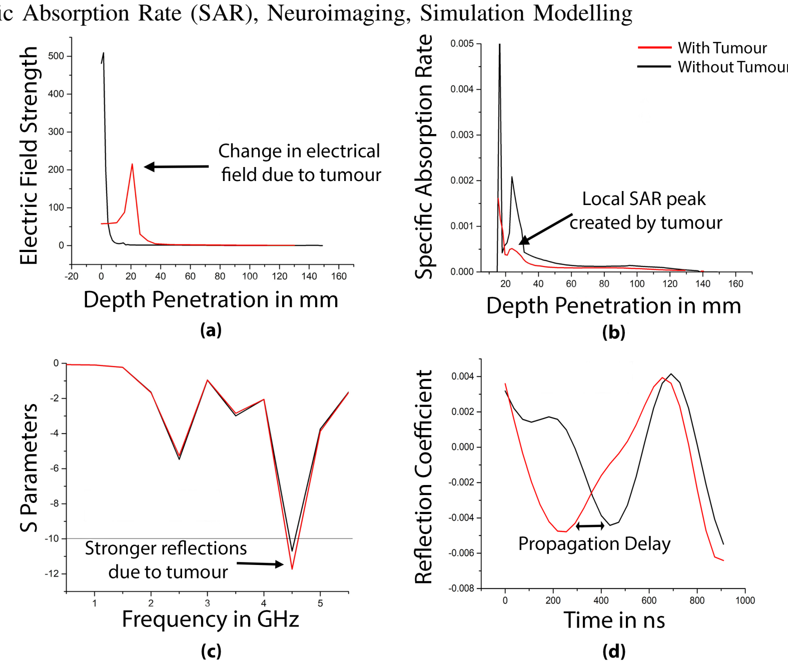
Despite the effectiveness of traditional methods such as MRI and CT scans, high cost and radiation risks persist. Our study investigates radar technology, using Patch antennas, as a non-invasive alternative for brain tumour detection, potentially enhancing safety and accessibility in diverse environments. Utilising Ansys Hfss, we modelled a human head with distinct cranial layers and a simulated tumour, across 0.5 to 5GHz frequency range.Results indicated that the presence of a tumour can alter electromagnetic wave propagation, including changes in reflection and transmission coefficients and a 200-nanaosecond delay in signal transmission.While promising, the reliance on a standardised head model in simulation suggests the need for further research with diverse patient-derived models.

Index Terms

Radar Brain Imaging, Tumour Detection, Specific Absorption Rate (SAR), Neuroimaging, Simulation Modelling



(I)



(II)

Fig. 1: (I) - Radar System , (II) - Results with and without tumour (a) Electric Field Strength (b) Specific Absorption Rate (SAR) (c) Reflection Coefficient (d) Propagation Delay

I. Summary

This study investigates the potential of radar technology, utilising Patch antennas, as a cost-effective and non-invasive alternative to conventional brain imaging techniques like MRI and CT scans, which are limited by high costs and significant radiation risks. Highlighting the potential for enhanced safety and accessibility, the research leverages advancements in electromagnetic wave penetration and imaging clarity to accurately detect brain tumours, particularly beneficial in diverse and resource-limited settings. Employing Ansys HFSS, we developed a detailed simulation of a human head, featuring seven cranial layers each with specified dielectric properties and included a simulated tumour between the Dura and CSF layers. Operating within a frequency range of 0.5 GHz to 5 GHz, the setup used a Patch antenna positioned 10mm from the head model in a forward scatter configuration, optimising the detection of reflected signals for a precise analysis of tumour influence on electromagnetic wave behaviour.

Our results indicate that the presence of a tumour significantly alters electromagnetic wave propagation, characterised by increased absorption and scattering, and changes in both the reflection (S11) and transmission (S21) coefficients. Additionally, the study observed a notable 200-nanosecond delay in signal transmission and significant variations in Specific Absorption Rate (SAR) and electric field strength, suggesting that tumours not only affect the phase shift and reflection of electromagnetic signals but also modify absorption patterns within the head. These findings confirm the potential effectiveness of radar technology with Patch antennas for tumour detection. However, the reliance on a standardised head model is a significant limitation, highlighting the need for future research to incorporate a broader range of head models derived from actual patient scans and to include real-time data and dynamic brain activities to enhance the validity of the findings. The potential integration of machine learning algorithms for automated tumour detection also promises to establish radar technology as a preferred method in clinical diagnostic processes, addressing the critical need for safer and more accessible brain imaging alternatives.