A model for functional imaging of breast by microwave radiometry

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Functional imaging of breast has been proposed as a complementary modality for early cancer detection. In principle microwave radiometry, i.e. passive detection of spontaneous thermal radiation from a body in the microwave frequency band, can provide information on the thermal status of mammalian tissue to a depth of about 3-4cm. During a typical session the radiometric signal is received by an antenna which is scanned on the surface of the breast. In this paper we theoretically discuss the potentiality of this technique.

The signal s that is collected by a matched antenna (F. Bardati et al., URSI General Assembly, New Delhi, Nov. 2005) is the sum (integral) of individual signals that are contributed by tissue elements dV at temperature T according to

$$s = \iiint_{\Omega} WT\, dV$$

where Ω is the overall volume that is sensed by the antenna at each position. W is a function that weights the elemental contributions decreasing with the increase of distance of an element from the antenna. W can be evaluated after suitable normalisation when we know the microwave power deposition (or the SAR, specific absorption rate) when the antenna radiates into the body in active modality. In particular the size of Ω depends on the size of the antenna. The presence of a malignancy may result in an excess of temperature ΔT as well as in a change ΔW, due to a change in permittivity of tumour tissue in respect to normal tissue. In order the thermal anomaly to be detected the change Δs in the radiometric signal must be larger than the radiometric sensitivity.

To appreciate ΔT we modelled a mammalian tumour as a sphere of diameter D having thermal parameters (metabolic heat generation, blood perfusion, thermal conductivity) found in the literature. The sphere was located at various depths and the size was in the range $6 \le D \le 12$ mm. The antenna was modelled as a circular aperture. Δs was evaluated for various diameters of the antenna and compared with the radiometric resolution.

Computations have been performed for a half-spherical model of breast on a thorax. The bio-heat equation has been solved by a commercial finite-element numerical code while the SAR has been evaluated by a proprietary FDTD code. We used the parameters of our new radiometer: frequency 2.6 GHz and sensitivity 0.035 K for 10s integration time. Preliminary results show that a 12mm lesion is visible up to about 30mm from the breast surface using a 3cm aperture.