Temperature profile retrieval in biological object using multi-frequency microwave radiometry

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A non-invasive temperature measurement method is desired for hyperthermic treatment of cancers. A temperature profile retrieval method using multi-frequency microwave radiometry has been investigated for this purpose. A multifrequency microwave radiometer measures thermal radiation coming from a biological objects as brightness temperatures. A temperature profile in tissues are retrieved from brightness temperatures using a model fitting method. In this method, the use is made of a temperature profile model function which is considered appropriate to describe temperature profiles expected under given heating conditions on the basis of previous experiences. This approach allows one to gain on the precision for the expense of the generality of solution. An influence of random fluctuations in the radiometric measurements on the estimated temperature profile is analyzed by a Monte Carlo technique to obtain its 2σ intervals. We use the 2σ intervals as a measure of the precision of the tissue temperature measurement. Our method was supported by experiments in which temperature profile in an muscle equivalent agar phantom was measured using a 5 band microwave radiometer. A typical result showed that the radiometric result is in a good agreement with the thermocouple measurements inserted into the phantom and the 2σ intervals is less than 1.9℃ over a range from 0 to 4 cm depth.

The temperature profile retrieval is tested by numerical simulations aginst animal experiment and clinical gyperthermia data reported elsewhere. The results showed that the microwave radiometric technique can be used effectively to measure temperature profiles in tissues over a 0 to 4.5 cm depth range. the numerical simulations using weighting functions based on an FDTD 3D field analysis are also tested. The 2σ intervals are considerably wider with new weighting functions than plane-wave approximations one. In order to reduce the 2σ intervals, it is effectivde to use a new model function, large aperture antenna with a 0.5 cm bolus thickness and 0.8 GHz measurement band. The result showed microwave radiometry can achieve 2σ intervals<1.6℃ over a range from 0 to 4 cm depth. This result indicates that the radiometric method will be useful for non-invasive temperature measurement in clinical hyperthermia.