FDTD Wideband Dispersive Modeling of Human Body

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With the recent rapid increase in the public concern for the interaction of electromagnetic (EM) waves and biological bodies, bio-EM researches have been carried, including hyperthermia, implanted antennas, and breast cancer detection. Previously, based on a *quadratic* complex rational function, we developed a dispersive modeling suitable for human tissues in the frequency range from 400 MHz to 3GHz. In this work, in order to cover wide frequency ranges, we extend the complex rational function into a *quartic* polynomial. We choose the frequency of interests as 100 kHz - 10 GHz, covering current medical applications.

Coefficients of a quartic complex rational function (QCRF) for various human tissues can be determined by a complex-curve fitting (CCF) technique, where 9 by 9 matrix inversion is carried out without the necessity of initial values. However, it turns out that a direct application of CCF to the 4-pole dispersion model with evenly-spaced sampling data leads to inaccurate dispersion of many human tissues at low frequencies. For the sake of a better curve fitting of QCRF model, we introduce a weighting factor (WF) in the matrix solving equation of QCRF model, defined as $WF(\omega_i)=1/(\omega_i)^{\alpha}$, where ω_i means a (evenly-spaced) sampling point and α is a coefficient to be determined. And then the Newton iterative method is applied to determine a proper WF.

We compare un-weighted QCRF ($\alpha=0$) with Newton-optimized QCRF ($\alpha\neq0$) for the dispersion accuracy of various human tissues. The proposed Newton-optimized QCRF dispersion model shows a good agreement with measurement data. For example, the root-mean-squared (RMS) error of Newton-optimized QCRF is 0.23% and the RMS error of un-weighted QCRF is 95.46% for stomach. Finally, we will also discuss how to apply the proposed FDTD dispersion model to numerical human phantoms. [Acknowledgments: This research was supported the KCC (Korea Communications Commission), Korea, under the R&D program supervised by the KCA (Korea Communications Agency) (KCA-2011-11911-01109).]