

Advanced Human RF Exposure Assessment using FDTD and Polynomial Chaos Expansion.

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Nowadays new wireless communications systems that are using Radio Frequency (RF) Electromagnetic Fields (EMF), such as smart phones, tablets, laptops are intensively used with versatile usages. Despite the existing protection limits and this increasing usage of wireless systems, there is a public concern about possible health impacts of the RF EMF exposure.

To respond to this risk perception large efforts have been conducted to assess the human exposure. Taking advantages of the improvement of computers performances important efforts have been carried out to assess the exposure using numerical simulations (a.k.a. numerical dosimetry) and in particular the finite difference in time domain (FDTD) method to calculate the specific absorption rate (SAR). The large progresses in High Performance Calculation and in particular those obtained using the graphical processor units have strengthened this tendency. During the past ten years realistic human voxel phantoms, including child models, based on medical images, have been developed for numerical SAR estimation. To handle realistic postures, representative of real configurations, deformation tools have been developed. At the end, such improvements in numerical dosimetry has left thinking that it was possible to simulate the exposure linked to the versatile usages of wireless communication systems, all the more so that the objective of dosimetry has been for a long time the compliance assessment with limits using worst cases. But even with the today calculation performances described previously, the time computation of the FDTD and its pre-processing does not allows computing all the possible cases.

The numerical dosimetry is therefore nowadays facing challenges that request new methods. The usual methods used to handle the characterization of the consequences of such variability (e.g. morphologies, the postures variations and of course the RF source location), such as the Monte Carlo method, requests nevertheless a large number of simulations that FDTD time computation does not support. The combination of Polynomial Chaos Expansion (PCE) and FDTD simulations allow building a surrogate model having a computational time compatible with the Monte Carlo approach. Such surrogate model can be substituted to the FDTD to overcome the limits described previously.

The challenge is therefore to build a surrogate model with a parsimonious approach due to the high FDTD computation time. The truncated Generalized PCE [B. Sudret, HDR, 2007. J. Silly-Carette et al. 2009. *IEEE MWCL*, 19 (4). P. Kersaudy et al 2014 *IEEE AP* 62(12)] combined with experimental design, the Least Angle Regression (LARS) algorithm used to identify the most influential polynomials, regression techniques to calculate the polynomial coefficients and the Leave One Out Cross Validation can help to achieve this objective [Wiart Joe et al, *e-Fermat* 2015 & *EUCAP* 2015. P. Kersaudy et al 2015 *Journal of Computational.*]. This approach has been used to characterize the scattered field by building facades [P. Kersaudy et al *IEEE* 2014 *AP* 62(12)], the statistical distribution of the exposure induced in the brain and genital organs [A. Ghamni. PHD 2013] by a mobile phone located close to the head or in a pocket.