Multidimensional collocation stochastic method to evaluate the Whole Specific Absorption Rate for a given population

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INTRODUCTION

To protect people from Electromagnetic Fields (EMF), ICNIRP has defined limits [1]. The Basic Restrictions (BR) set the maximum values of Specific Absorption Rate (SAR). Since BR are complex to assess ICNIRP has also derived the reference levels (RL) from BR. These RL were established to guaranty the compliance to BR. Several studies with human model (phantoms) show that even below the RL, the WBSAR (Whole Body averaged SAR) may exceed the BR due to the variability of human morphology [2]. The number of phantoms is very limited. Hence, the characterization of the WBSAR for a given using usual methods such as Monte Carlo is not possible. To bridge this lack of phantoms a model for the WBSAR as a function of morphology is suitable. However, this model requires knowledge on internal morphology (proportion of fat, muscle…) and external ones (mainly height and weight) [5]. Due to the absence of statistical data concerning the internal morphology, the statistical distribution of the WBSAR is difficult to obtain.

In this paper, the internal morphology is released by considering one equivalent tissue for the whole body. The stochastic collocation is used to characterize the distribution of the WBSAR for a given population. The study is conducted in the case of a plane wave operating at 2.1 GHz, vertically polarized and frontally oriented on phantoms. The incident power is equal to 1W/m².

MATERIALS AND METHODS

In this study parametric laws such as Gaussian and log-normal laws are extracted from an anthropometric database of 3800 adults collected in France. The factors used in this study are: height, chest and front shoulder breadth and are denoted respectively denoted X_1 X_2 and X_3. These factors are dependent. The correlation matrix is denoted C.

A morphing technique is used to deform the phantoms using $X_{i},_{i=1,..,3}$.

The spectral decomposition is written as follow:

$$\mathrm{WBSAR}(\Omega) = \sum_k \beta_k \Psi_k(\Omega) \qquad \textbf{(1)}$$

where Ψ_k are the multidimensional chaos polynomial [3], β_k the modal coefficients and is the modal coefficients and are the Ω stochastic variables. To estimate the modal coefficients, the quadrature method or regression is used.

Concerning the stochastic variables, the Sparse Grid Clenshaw Curtis (SGCC) is used [4]. The advantage of SGCC is to use imbricate points which imply that all points have not to be simulated again when the calculation requires moving to higher order for the quadrature. Fig.1 resumes the spectral method.

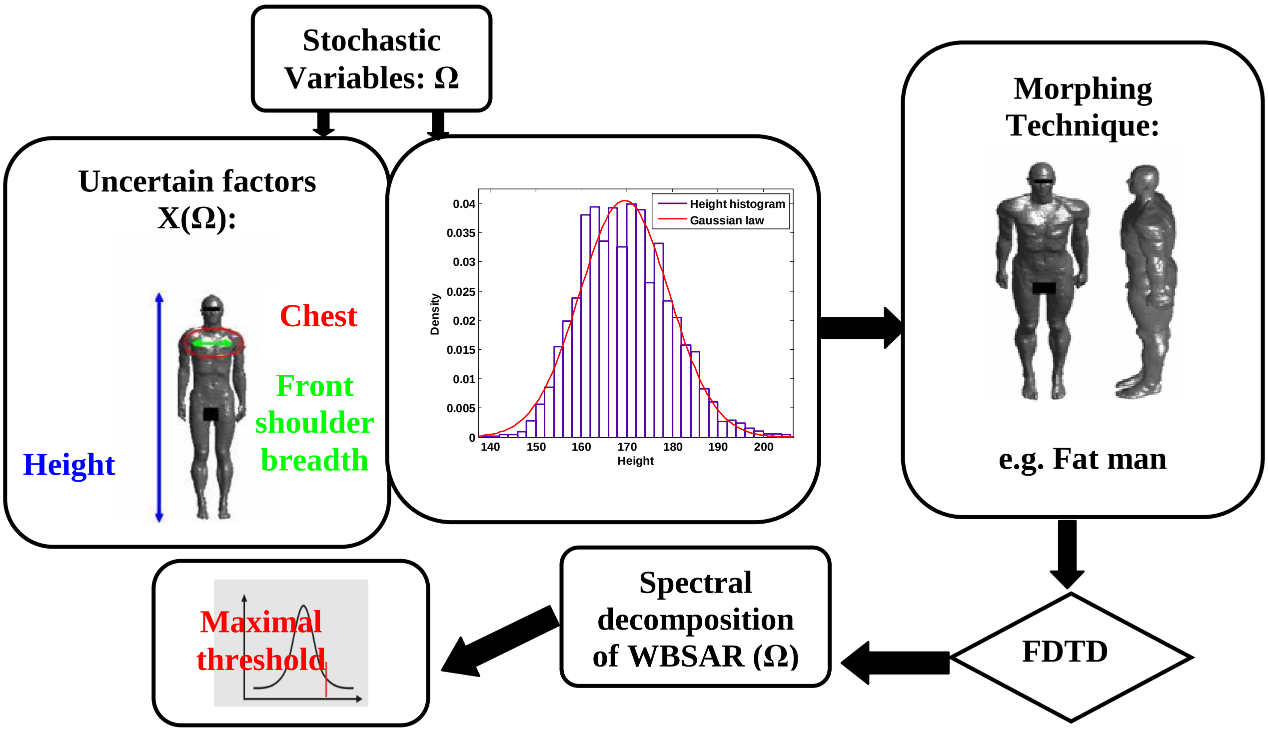

Fig.1: Scheme of the spectral method.

FIRST RESULTS

To consider the dependence in the stochastic variables, the transformation (2) is used:

$$\Omega = \begin{pmatrix} \omega_1 \\ \omega_2 \\ \omega_3 \end{pmatrix} = \sqrt{C} \begin{pmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \end{pmatrix} \quad \textbf{(2)}$$

where $\sqrt{C} = P^{-1}.D^{\frac{1}{2}}.P$ (matrix diagonalization). ζ_1, ζ_2 and ζ_3 are the independent variables obtained by SGCC. Simulations are in progress. The study will allow us to obtain the WBSAR distribution.

CONCLUSIONS

The aim of this study is to determine the maximal threshold of the WBSAR for the French population. This approach will enable us to well make out the influence of the external morphology on the WBSAR as well as its maximal threshold for a given population. The objective is to apply the same analysis using ellipsoids and compare the both.

REFERENCES

[1] ICNIRP 1998 Guidelines for Limiting Exposure to Time Varying Electric Magnetic and Electromagnetic Field (up to 300 GHz). *Radiation Protection Health Physics*, 74, 4:494-522.

[2] Conil E, Hadjem A, Lacroux F, Wong MF and Wiart J. 2008 "Variability analysis of SAR from 20MHz to 2.4GHz for different adult and child models using FDTD". *Phys. in Med. and Biol.*, 53 1511-1525.

[3] Sudret B, "Uncertainty propagation and sensitivity analysis in mechanical models-Contributions to structural reliability and stochastic spectral methods. *Université Blaise Pascal, Clermont-Ferrand*, 2007.

[4] Silly-Carette J, Lautru D, Gati A, Wong M-F, Wiart J, Fouad Hanna V, "Determination of the Uncertainty On the Specfic Absorption Rate using the stochastic collocation method and the FDTD, IEEE AP-S international Microwave Symposium", San Diego, 2008.

[5] El Habachi A, Conil E, Hadjem A, Vazquez E, Gati A, Fleury G, Wiart J, "Statistical Analysis of the Whole Body Absorption Depending on Anatomical Human Characteristics", *Phys. in Med. and Biol.*, submitted.