Electro-thermal Finite Element Analysis for biomedical application. Reconstruction of a phantom: from EM safety up to treatment planning

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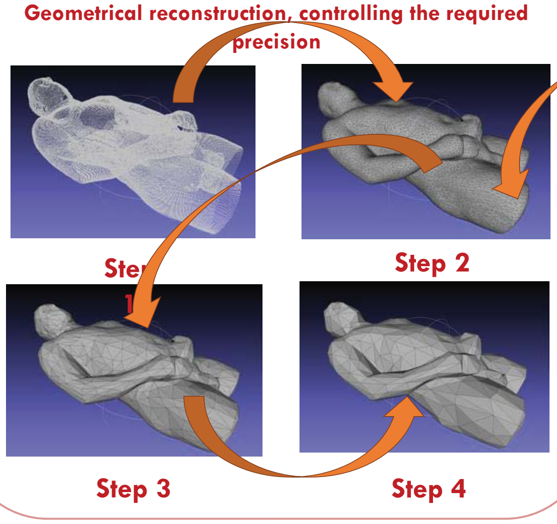
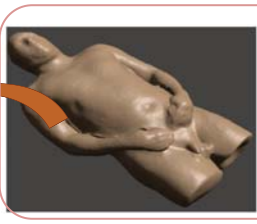
Abstract

Thanks to the rapid growth of the computer hardware resources, nowadays it is possible to create numerical phantoms of human bodies which are sophisticated enough to guarantee an high level of computational accuracy. In case of bio-electromagnetic compatibility, the implemented models can be used to assess realistic conditions of exposure for common situations in real life (e.g. expsosure due to a telecommunication device, microwave oven leakage, etc.), or for analyzing the conditions under electromagnetic therapy (e.g. hyperthermia, electrostimulation, etc). In this poster, we show the main steps of numerical implementation that are necessary to obtain reliable results from a large-complex 3D multiphysical coupled model of a human body.

Geometrical reconstruction, controlling the required precision





Reparation of topological errors:

non-manifold edges, volume intersections,…

Step1 – Step2 : from cloud points to trangular connectivity

Step2 – Step3 : from connected surface to reduced number of vertices

Step3 – Step4 : from reduced number of vertices to an optimized set of vertices

Verification of the mathematical formulation:

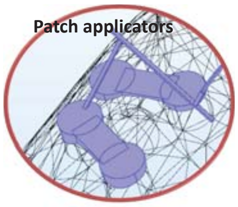
$$\lambda_{0j} = \frac{c}{f_j} = \frac{1}{f_j\sqrt{\epsilon_0\mu_0}} >> d_* \quad j = 1,\dots,m$$

$$\delta_{ij} = \frac{c}{2\pi f\sqrt{\frac{\epsilon_i}{2}\left[\sqrt{1+\left(\frac{\sigma_i}{2\pi f_j\epsilon_i}\right)^2}-1\right]}} > d_{el} \quad i = 1,\dots,n \quad j = 1,\dots,m$$

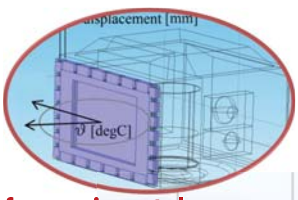
$$\gamma_{ij} = \frac{\sigma_i}{2\pi f_j \epsilon_i} >> 1 \quad i = 1,\dots,n \quad j = 1,\dots,m$$

Possible emitting devices

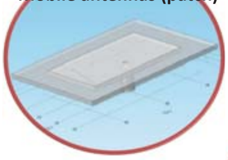
Patch applicators



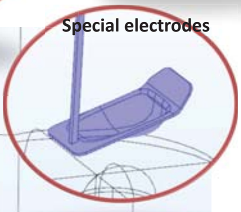
Leakage from microwave oven



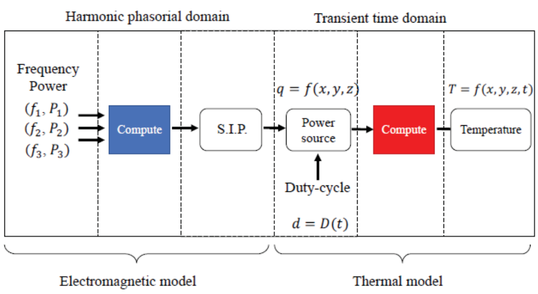
Mobile antennas (patch)



Special electrodes

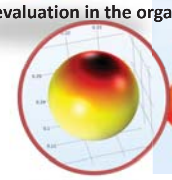


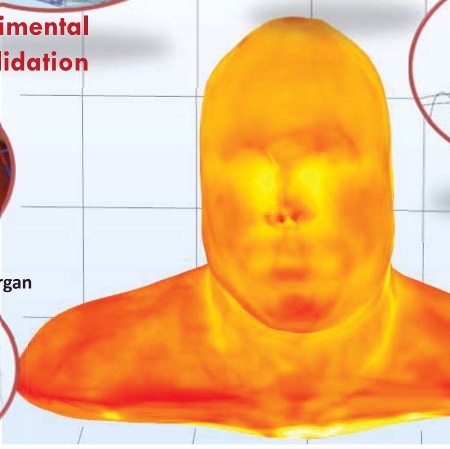
Multiphysics domain analysis



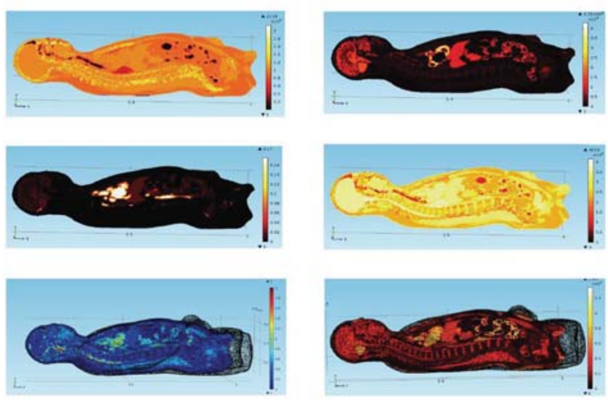
Example of experimental trial for model-validation

Direct evaluation in the organ





Reconstruction of the material properties



Comments

Based upon the numerical predictions that can be made with the reconstructed numerical model, it has been possible to obtain practical information under certain exposure conditions (the detailed results have been already submitted to Scientific Journals). As any CAE user knows, ***validation is a fundamental*** issue before analyzing the numerical results. Indeed, simplified experimental trials must be constructed and used to calibrate, and then to validate the implemented model.