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ABSTRACT: Human exposure to low-frequency magnetic field: new methodologies for numerical dosimetry.

Nowadays, human beings are inevitably exposed to electromagnetic fields due to the large diffusion of electric and electronic devices. When electromagnetic fields come into contact with human bodies, an interaction occurs and adverse health effects depending on the field intensity and the exposure time may happen.

In recent years the main world organizations, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute of Electrical and Electronics Engineers (IEEE), which are involved in research regarding human exposure to electromagnetic fields, have defined guidelines and standards for human protection. These guidelines and standards are based on scientific studies carried out by researchers who, through numerical dosimetry, are able to perform numerical simulations and to evaluate the dosimetric quantities inside the human body. Threshold values are established to ensure a safe human exposure and a protection against the possible adverse effects that would arise in the exposed individual.

In this thesis the assessment of human exposure to low-frequency electromagnetic fields is taken into account. Some of the main problems related to the numerical dosimetry are discussed and different approaches are proposed.

A comparison between two different methods that allow to evaluate the magnetic vector potential starting from the knowledge of the magnetic flux density is described and the pros and cons of both methods are analyzing by solving a numerical dosimetry problem performed with virtual and real measurements.

Subsequently, shifting the attention to the voxelized realistic human models used in numerical simulations, the stair-casing approximation error due to the voxel-based discretization of these models is analyzed and tetrahedral models are introduced. The studies show that tetrahedral human models are able to eliminate numerical artifacts produced by stair-casing effects. However, other sources of computational artifacts are still present in real exposure scenarios and post-processing techniques are still needed.

Finally, the posturing problem related to human models is taken into account. Although the posture of the human body plays a fundamental role in numerical dosimetry problem, posture modeling takes a long time and some approximation errors are inevitably introduced. In this thesis, a new approach based on performing computations by using a non-postured human model is analyzed. The source term is modified through appropriate geometric transformations to avoid the posturing step in the numerical simulations. Several numerical simulations on 2D and 3D domains are performed by using simplified phantom and realistic human body in order to validate the new approach. The potentiality of this new approach is highlighted and the possible applications are presented.