Deterministic 3D Ray Launching EMF/Human Body Interaction Estimation in Complex Scenarios

Erik Aguirre(1), Peio Lopez Iturri(1), Leire Azpilicueta(1), Silvia de Miguel-Bilbao(2), Victoria Ramos(2) and Francisco Falcone* (1,3)
(1) Electrical and Electronic Engineering Dept., UPNA, Navarre, Spain
(2) Telemedicine and E-Health Research Unit, Institute Carlos III, Madrid, Spain
(3) Institute for Smart Cities, UPNA, Navarre, Spain
*corresponding author e-mail: francisco.falcone@unavarra.es

INTRODUCTION

The use of wireless technology has become increasingly popular, for a wide variety of uses such as communication systems (public land mobile networks, wireless local area networks, wireless sensor networks) or wireless power transfer systems. Moreover, the advent of Context Aware scenarios, such as those envisaged in Ambient Assisted Living or in Smart Cities, rely on the deployment of a very large amount of transceivers in close vicinity to the human body, which interconnect with multiple wireless systems in a Heterogeneous Network (HetNet) configuration. The assessment of in terms of dosimetric estimation for non-ionizing EMF is in this case influenced no only by the complexity of the scenario under analysis, but also by the potentially large amount of low power transceiver which can be deployed.

In this work, estimation of EMF and human body interaction is presented for large, complex scenarios, with the aid of an in-house implemented deterministic electromagnetic code, in which a simplified human body is introduced. The technique is suitable for multiple types of scenarios and systems, such as domestic indoor environments, vehicular scenarios or high density outdoor urban scenarios.

MATERIALS AND METHODS

The estimation of EMF intensity is obtained by the use of an in-house simulation tool based on deterministic 3D Ray Launching code, which is an approximation of Geometric Optics and Uniform Theory of Diffraction. Simulation scenarios include object shapes as well as their dispersive electromagnetic parameters, such as conductivity and dielectric permittivity. A simplified human body model, including dispersive material parameters has also been implemented, in order to assess the EMF/human body interaction in the overall field estimations, has been implemented and is schematically shown in Figure 1. Several scenarios have been tested, such as interior of vehicles [1-2] and indoor scenarios with interference sources, such as a microwave oven with radio frequency power leakage[3] or EMF exposure due to WiFi based wearables[4].

RESULTS

The combined effect of scenario complexity and inclusion of human body model leads to distribution of EMF values which are highly dependent on the location of the transceivers/interference sources, the configuration of the scenario in terms of object location and material description and the density and placement of the individuals within the scenario. As an example, the EMF estimations for an indoor scenario with an active source (operating microwave oven) is depicted in Figure 1. As it can be seen, field distribution is non-uniform, mainly due to multipath propagation and scattering effects, which can dominate in complex indoor environments. The use of deterministic based approach such as 3D Ray Launching enables to consider the topological dependence even in the case of very large scenarios in terms of operating wavelength, a typical limitation in other full wave approaches.

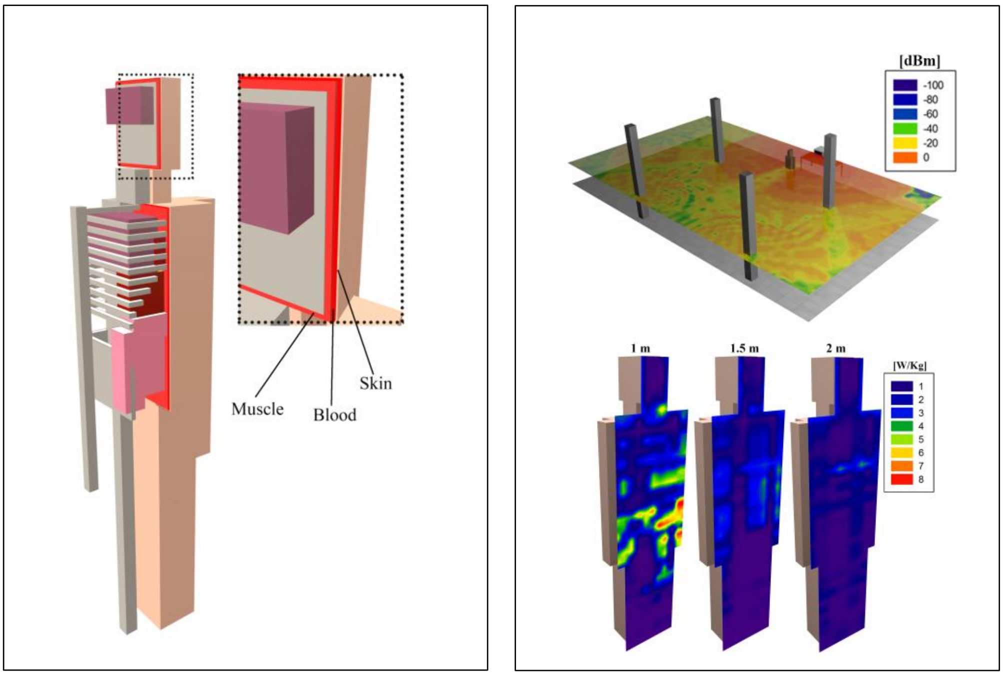

Figure 1: Detail of the Simplified Human Body model implemented and coupled to the 3D Ray Launching Code. Estimations of E-Field values and SAR at human body model surface for an indoor scenario with an operating microwave oven.

CONCLUSIONS

The use of deterministic techniques coupled to a simplified human body model provide adequate estimations in terms of field level estimations in large complex scenarios, in which the EMF/human body interaction can be accounted for. This method is applicable to very large scenarios and can be extended to other types of interaction, such as in-body EM pulse propagation and to the analysis of other effect, such as coupling to bio-heat equation.

REFERENCES

[1] Erik Aguirre, Peio Lopez Iturri, Leire Azpilicueta, Silvia de Miguel-Bilbao, Victoria Ramos, Uxue Gárate and Francisco Falcone, “Analysis of Estimation of Electromagnetic Dosimetric Values from Non-Ionizing Radiofrequency Fields in Conventional Road Vehicle Environments”, Electromagnetic Biology and Medicine, January 2014, doi:10.3109/15368378.2013.863782

[2] Erik Aguirre, Javier Arpón, Leire Azpilicueta, Peio López, Silvia de Miguel, Victoria Ramos and Francisco Falcone, “Estimation of Electromagnetic Dosimetric Values from Non-Ionizing Radiofrequency Fields in an Indoor Commercial Airplane Environment”, Electromagnetic Biology and Medicine, doi:10.3109/15368378.2013.810155, August, 2013

[3] Peio Lopez-Iturri, Silvia de Miguel-Bilbao, Erik Aguirre, Leire Azpilicueta, Francisco Falcone, and Victoria Ramos, “Estimation of Radiofrequency Power Leakage from Microwave Ovens for Dosimetric Assessment at Nonionizing Radiation Exposure Levels,” BioMed Research International, vol. 2015, Article ID 603260, 14 pages, 2015. doi:10.1155/2015/603260

[4] Silvia de Miguel-Bilbao, Erik Aguirre, Peio Lopez Iturri, et al., “Evaluation of Electromagnetic Interference and Exposure Assessment from s-Health Solutions Based on Wi-Fi Devices,” BioMed Research International, vol. 2015, Article ID 784362, 9 pages, 2015. doi:10.1155/2015/784362