Science Fund of the Republic of Serbia
Serbian Science and Diaspora Collaboration Program: Knowledge Exchange Vouchers

Project - Optimising biomedical applicators for cancer care - OPTICARE

Research field of the Project: computational electromagnetics, human tissues characterization, electromagnetic hyperthermia

Name of the Scientific Research Organization (SRO) from Serbia: Faculty of Electronic Engineering, University of Niš
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Name of the Project Partner – expert from diaspora: Dr Ana Vuković, Associate Professor
Name of the Host Institution (HI): George Green Institute for Electromagnetics Research, Faculty of Engineering, University of Nottingham, UK
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Abstract:
The aim of the project is to design an optimal multi-antenna microwave applicator for hyperthermic treatments of cancer. A combination of the advanced electromagnetic (microwave) and thermal models will be used in the design to provide that the required level of heating is most efficiently reached in the area of interest. The design stage requires a multi-physics approach, namely electromagnetic and thermal and these will be developed in the framework of the Transmission Line Modelling (TLM) method in which both project team and partner have major expertise.

Project objectives:
It is well known that electromagnetic (EM) fields can have both harmful and beneficial effects on human body. These conflicting effects impose requirement that new EM-based medical devices must be carefully designed to offer less invasive and safer healthcare. The ability to use computational methods that can accurately design medical devices and predict their impact on human body (thermal properties and Specific Absorption Rate - SAR) is of major importance for a safe deployment of medical devices and equipment.

The aim of this project is to design an optimal multi-antenna applicator for hyperthermic treatments of cancer and thus contribute to improving health care. The design aspect has to account for several issues and these are: a) accurate characterization of EM field propagation through biological materials i.e. human tissues, that have lossy and dispersive and in some cases anisotropic properties; b) multi-physics aspect of microwave heating i.e. interaction of EM and thermal conduction and c) account for large scale models and complex shapes of the human body.

Therefore, the main scientific objectives of this project are:

- Implement accurate dielectric models of human tissues that are anisotropic, lossy and dispersive into the core algorithms of TLM/UTLM method. This will require knowledge of tissue parameters collection which is also part of this project. The accuracy of the models will be confirmed by comparison with available research data.
- Develop TLM-based heat-transfer model to account for distributions of absorbed EM energy and temperature inside the specific parts of human body and to predict the Specific Absorption Rate of biological tissues and compare with available results from literature.
- Combine the tetrahedral mesh with cubically or cylindrically meshed regions for efficient computational discretization and modelling of human body.
- Produce an optimal design of resonant cavity-based microwave applicator together with one prototype of antenna intended to be used in hyperthermic chamber.
- Compare results with GGIEMRs software, UTLM. This will allow for the broader problem space to be explored in particular applicators that are not cylindrical in shape and exploration of very large problems on GGIEMR supercomputer capabilities.

The advanced modelling capability transfer of UTLM software from GGIEMR to FoEE.

Project team members:

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Publications:

1. Jugoslav J. Joković, Tijana Z. Dimitrijević, Aleksandar S. Atanasković, Nebojša Dončov, “Computational Modeling of the Bent Antenna in an On-body Mode using the Cylindrical TLM Approach”, Mathematical Problems in Engineering, Hindawi, vol. 2022, Article ID 8486740, 7 pages, 2022, doi: 10.1155/2022/8486740, https://downloads.hindawi.com/journals/mpe/2022/8486740.pdf, OPEN ACCESS

2. Jugoslav Joković, Tijana Dimitrijević, Aleksandar Atanasković, Nebojša Dončov, Ekrem Altinozen; Ana Vukovic; Phillip Sewell, “Transmission Line Modelling of an Eccentrically Loaded probe Coupled Cylindrical Cavity”, Proceedings of the International Symposium on Industrial Electronics and Applications, INDEL 2022, Banja Luka, Bosnia and Hercegovina, 2022, pp.1-4, doi: 10.1109/INDEL55690.2022.9965465, https://ieeexplore.ieee.org/document/9965465

3. Tijana Dimitrijević, Jugoslav Joković, Aleksandar Atanasković, Nebojša Dončov, Ana Vuković, "TLM Mesh Impact on Textile Antenna Modelling", Proceedings of the 21st Mediterranean Microwave Symposium MMS 2022 co-sponsored by European Microwave Association (EuMA), the IEEE Italian Chapters on “Antennas and Propagation/Electronic Devices Microwave Theory and Techniques” (AP/ED/MTT) and on “Antennas and Propagation/Microwave Theory and Techniques” (AP/MTT), May 9-13, 2022, Pizzo Calabro, Italy, doi: 10.1109/MMS55062.2022.9825621, https://ieeexplore.ieee.org/document/9825621

4. Ana Vukovic, Ekrem Altinozen, Tijana Dimitrijevic and Phillip Sewell, "Simulation Platform for Flexible Electronics", Proceedings of the 15th International Conference on Advanced Technologies, Systems and Services in Telecommunications, TELSIKS 2021, Niš, Serbia, October 20-22, 2021, pp. 135-138, ISBN: 978-1-6654-4442-2, doi: 10.1109/TELSIKS52058.2021.9606324, https://ieeexplore.ieee.org/document/9606324

5. Tijana Dimitrijević, Ekrem Altinozen, Aleksandar Atanasković, Jugoslav Joković, Ana Vuković, Phillip Sewell, Nebojša Dončov, "Modelling of Conformal Antennas using Time-Domain TLM Method", Proceedings of the 8th International Conference on Electrical, Electronic, and Computing Engineering, IcETRAN 2021, Ethno village Stanišići, Republic of Srpska, September 8-10, 2021, pp. 375-378, MTI1.2 – 4 pages, ISBN: 978-86-7466-894-8, https://www.etran.rs/2021/zbornik/Proceedings/Zbornik_Proceedings.pdf

6. Jugoslav Joković, Tijana Dimitrijević, Aleksandar Atanasković and Nebojša Dončov, "TLM modelovanje deformacija savijanja antene u biomedicinskim aplikacijama", Zbornik radova 66. godišnje konferencije za elektroniku, telekomunikacije, računarstvo, automatiku i nuklearnu tehniku, ETRAN 2022, Novi Pazar, Srbija, 6-9. jun 2022, pp. MT1.2 – 5 pages, ISBN: 978-86-7466-930-3, https://www.etran.rs/2022/wp-content/uploads/2022/06/ZBORNIK_ETRAN_22_RADNO_FINAL.pdf

7. Tijana Dimitrijević, Aleksandar Atanasković, Chris Smartt, Jugoslav Joković and Nebojša S. Dončov, “Validation of the Junction Wire Network Model Implemented in the Cylindrical TLM Method”, Proceedings of the 2022 IEEE MTT-S International Conference on Electromagnetic and Multiphysics Modeling and Optimization (NEMO2022), Limoges, France, pp.141-144, 2022, ISBN: 978-1-6654-8633-0

8. Ana Vukovic, Phillip Sewell, Tijana Dimitrijevic, Ekrem Altinozen, Kaiqi Yan, "Recent Advances in the Unstructured Transmission Line Modelling (TLM) Method", 2022 IEEE MTT-S International Conference on Numerical Electromagnetic and Multiphysics Modeling and Optimization (NEMO), July 6-8, 2022, Limoges, France. ISBN: 978-1-6654-8633-0