Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Ioannis Georgakis

PhD Program: Computational and Data Science and Engineering

Title of Thesis: Fast integral equation methods and performance bounds of modern magnetic resonance coils

Supervisor: Prof. Maxim Fedorov

Co-advisor: Prof. Athanasios Polimeridis

Chair of PhD defense Jury: Prof. Ivan Oseledets ***Email****: I.Oseledets@skoltech.ru*

Date of Thesis Defense: 28 November 2019

Name of the Reviewer: Francesca Vipiana

I confirm the absence of any conflict of interest	**Signature:** Francesca Vipiana **Date: 25-10-2019**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications

The summary of issues to be addressed before/during the thesis defense

Brief evaluation of the thesis quality and overall structure of the dissertation

The general objective of the Thesis is to accurately model the interactions between EM waves and biological tissues in order to be able to design, via high-efficient numerical simulations, sophisticated and tunable RF coil arrays for MR imaging.
This is a very challenging objective that is fully achieved by the Thesis through high-quality methods and introduced novelties. Moreover, the Thesis is well organized in a way that, even if the reader is not an expert of MRI, he/she can easily follow the proposed approaches and their application to the state-of-the-art research activities within RF coil arrays' design.

The relevance of the topic of dissertation work to its actual content

The main goal of the Thesis is to provide a software simulator able to design, in an accurate and efficient way, sophisticated and tunable RF coils. This design of the RF cools is inextricably linked to the design of the next-generation magnetic resonance (MR) scanners that, as shown in e.g. [87], have immense imaging capabilities. Hence, the topic of the Thesis has a significant relevance in the actual MRI community.

The relevance of the methods used in the dissertation

In the Thesis, a novel integral equation solver for the accurate computation of EM fields distributions within highly inhomogeneous bodies has been developed and deeply numerically tested. The proposed method combines a surface and a volume integral equation solver together with high-order basis specifically designed for high contrast and inhomogeneous dielectric objects. Moreover, novel performance metrics, related to the EM field distribution within the considered inhomogeneous dielectric body, have been developed and analyzed.
The methods developed within the Thesis represent the state-of-the-art in the topic of surface/volume integral equation solvers and they are of relevance for both the Computational Electromagnetic community as well as the MRI one.

The scientific significance of the results obtained and their compliance with the international level and current state of the art

The results obtained within the Thesis are the perfect link between the analytical electrodynamic simulations, extensively studied in literature, and full-wave numerical computations. The proposed numerical solver allows an accurate analysis of realistic and complex scenarios keeping rapid simulations, thanks to its efficient development and implementation. Hence, I consider the reached results top level international research.

The relevance of the obtained results to applications (if applicable)

The numerical tools developed in the Thesis can be the reference framework for a truly robust optimization of the next-generation RF coils, that will yield higher SNR and faster image acquisition without compromising patient safety and image quality.

The quality of publications

The quality of the reported publications is good: they include one journal paper published in MTT Trans. and two journal papers currently under review. The research activities were presented at international conferences such as EuCAP and ACES as well as to the annual meeting of the International Society for Magnetic Resonance in Medicine.

Minor text corrections

- In the abstract define “TXE”

- Check the titles of the cited papers: acronyms have to be capitalized (e.g. “Stable fft-jvie solvers for fast analysis of highly inhomogeneous dielectric objects,” should be “Stable FFT-JVIE solvers for fast analysis of highly inhomogeneous dielectric objects,”)

Provisional Recommendation

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate’s thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*