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: Vladimir Okhmatovski

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Signature:**  **Date: DD-MM-YYYY**

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

The dissertation by Ioannis Georgakis presents a comprehensive description of the state-of-the-art methods for RF coil design in both current and future MRI systems. Excellent coverage of the discussed topics with literature sources accompanied with insightful explanations of their relevance from the author will make the thesis a valuable resource for practitioners involved in work on improvement of RF coil designs. The thesis also has a strong innovative component. Papers describing new contributions are submitted for publication. The thesis is compliant with international standards on quality of subject matter treatment and level of innovation.

The *main contributions of the thesis* are in:

1) Introduction of new metric – ultimate intrinsic transmit efficiency (UITXE), which sets the upper bound for transmitter coils efficiency for a given region of tissues, is introduced. The UITXE provides quantitative figure of merit for various coil designs and shows how close they are to the ideal in terms of uniformity of provided field distribution for a given region of the imaged object.

2) Introduction of methodology for determining ideal current distribution on a given surface enclosing the object, that maximizes UITXE for a given region. Knowledge of such current distribution can guide the designer as to where to place the coils, which configuration they should have, and what best field uniformity can be achieved with them.

3) Development of robust framework for the generation of numerical basis for given realistic inhomogeneous objects which is complete for representation of arbitrary incident magnetic fields. Once such basis is created rapid evaluation of competing coil designs can be performed through expansion of their incident fields over this basis.

The quality of publications is hard to judge as the papers on the new contributions are still in review cycles and the journals they are submitted to are undisclosed.

The *strengths of the thesis* are:

a) Strong innovative content with in-depth treatment of proposed approaches and metrics both analytically for spherical object and numerically for realistically complex inhomogeneous human head model;

b) Both applied and computational aspects of the method are thoroughly developed;

c) Implementation of the developed methods in MARIE software which is made available for public use;

d) Detailed description of the concept and extensive review of pertinent literature;

e) Extensive support of proposed concepts with convincing numerical examples;

f) Future work directions are clearly outlined.

The *weaknesses of the thesis* are:

a) Lack of publications on the novel contributions of the thesis in the top-tier journals.

Thesis makes a strong contribution to the MRI technology and provides powerful techniques for advancing it through methods for systematic design of RF coils. The latter are critical components of MRI systems determining the quality of images it can achieve. Methods and metrics proposed in the thesis will likely be adopted by next generation of researchers and RF coil designers. Despite the fact that papers on the topics of the thesis are still under review, I unreservedly recommend the thesis for public defense.

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*