Skoltech
Skolkovo Institute of Science and Technology

Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Dmitry Popov

PhD Program: Engineering Systems

Title of Thesis: Topology and parameter optimization for additive manufacturing based on function representation

Supervisors: Professor Iskander Akhatov, Skoltech

Dr. Alexander Pasko, Skoltech

Name of the Reviewer:

I confirm the absence of any conflict of interest	**Date: 07-09-2022**

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

In the thesis, the author presents a collection of numerical methods and software tools that he developed based on the theory of function representation for the tasks of topology and parameter optimization of additive manufacturing processes. The thesis consists of seven chapters. Chapters 1 to 3 are introductory. They contain, respectively, the literature survey, a summary of the function representation theory, and the statements of objectives and novelty. Chapter 4 outlines the software framework architecture. Chapter 5 describes the optimization algorithm developed by the author and shows example optimization results. Chapter 6 describes the slicing algorithms developed by the author and presents a comparison with other methods. Thus, the novel results of the dissertation are mainly in chapters 4 and 5. Chapter 7 concludes the thesis.

The study is scientifically sound, the conclusions are supported by the results, the material is well organized and well presented. The actual contents of the dissertation are in accord with the topic declared in the title. The author extensively applies methods of computational geometry, which are relevant to the objective of the dissertation. It is constructively demonstrated that functional representation can reduce computational cost of geometrical data processing used in additive manufacturing, which is a scientific result of significance for practical applications. The main findings are published in reputable journals. I recommend that the candidate should defend the thesis. The following specific comments may be considered as suggestions for optional revisions.

1.   Page 54: "We can see that the modified algorithm is approximately twice as fast as the original one." Is it twice as fast for the same accuracy or for the same computational cost? Don't multiquadric splines present an approximation of a higher order than the bilinear spines? In any case, the accuracy and computational complexity should be discussed in the thesis.

2.   Page 56: "At the same time, both algorithms produce similar values of the objective function, differing in the third significant digit, depending on the optimization case." It seems to me that the two optimization algorithms use, respectively, two different approximate expressions for the objective function: one is based on bilinear splines, the other is based on multiquadratic splines. Am I right? If so, the author should discuss possible consequences, such as sensitivity to the grid resolution.

3.   Page 54: "see details in Appendix A of [Popov et al., 2021a]"; page 56: "These modifications are listed in Appendix B of [Popov et al., 2021a]"; page 83: "A more detailed description can be found in Appendix A of [Popov et al., 2020b]"; page 88: "can be found in Appendix B of [Popov et al., 2020b]." The author should include these appendixes in the thesis to make the document self-contained.

4.   Page 93: "Thus, the efficiency of adaptive criteria such as IA and AA increases with increasing precision of the calculated curve in one layer." The efficiency should be formally defined and quantified before making this claim. Figures 6-10 and 6-11 only show that the time increases with the increasing resolution. The time of computation using a regular grid with the finest resolution can be taken as the baseline, for instance.

5.   Page 93: "This means that with increasing model complexity, the use of adaptive methods become reasonable only with finer accuracy." Does this relate with the fractal dimension of the object?

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*

/Dmitry Kolomenskiy/