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 (Alternatively, Reviewer can formulate a possible conflict)	Jeng Ywan JENG **Date: 04-09-2022**

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

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

Other questions and comment

1. The function representation FRep is investigated for the AM modeling, simulation, topology and slicing. It is an interesting topic and could be potentially for the complicated function of AM system. In particular for the function of N-dimensional primitives, it can be very much powerful representation for AM enabled applications, like the multi-material or functional gradient material, periodical or non-periodical lattice cellular structure with functional (gradient) mechanical or variable material properties.
   Of course, this N dimensional primitive should/could be simplified into 3D coordinate system and to be benchmarked with general BRep. Therefore, it is clear to realize the capability and ability for commercially used in other single material process, like the traditional machining or forming processes.
2. In scientific thesis, it had better to be written in 3rd passive point of view, like the wording of "we" (active point of view--emotion) had better to be changed into it. For example, there are several wordings of "we" has been written in abstract. This problem is not happened just in abstract, but also in most of the sections.
3. In abstract, too few scientific information is expressed, like only "fast algorithms" is used. There is no more information about this scientific information and how good to be compared with others. And, what is problem of the existed algorithm is not described. Also, the achievement is not mentioned, so it is difficult to attract reader to continue for other sections. "function representation & FREP" seem important keyword and contribution in this research, it should be mentioned and briefly explained in abstract to make the abstract more comprehensive.
   If the abstract will be too long, the first section can be shortened about the general common sense.
4. P.14 BRep is the oldest approach for describing solid bodies used in CAD systems.—This statement is not absolutely correct in scientific thesis, in particular for this thesis is to focus on the topology of AM modeling.
5. In this section in P.14 about the relationship or logic from CSG and BRep to Function Representation is not clear. Even, this terminology of FRep will e explained in later section, which is not logically reasonable. https://en.wikipedia.org/wiki/Function_representation
6. The purpose of Table 1.1: Geometry representations in CAD systems is to show the BRep is used in most of CAD systems. This logic seems not absolutely reasonable. Please re-think about the problem 4.
7. P.31 The second important algorithm we need to consider is slicing. It is a procedure of CNC program generation. This statement is also scientifically questionable.
8. P.35 The class Structure stores more complex objects made of several primitives in a JSON format. What is this JSON format? It seems not defined before and not so popular in AM society.
9. The rendering of the proposed model is illustrated and explained in section 4.3 P.42., but it started from 3D instead of N-space with other functional representation. Is it possible to

design a FRep with variable functional lattice/cellular structure or even with variable material properties, like composite material with forming material filled in a close cell? Reference--Mayur Jiyalal Prajapati, AjeetKumar, Shang-ChihLin, and Jeng-YwanJeng, "Multi-material additive manufacturing with lightweight closed-cell foam-filled lattice structures for enhanced mechanical and functional properties", *Additive Manufacturing* Volume 54, June 2022, 102766.

10. P. 44 This tool assumes that the drawn objects consist of textured portions of surfaces, e.g. triangles, as in classical BRep. If this BRep can be replaced by STL, it seems more reasonable and strongly related to AM application, because triangle seems not the most popular in BRep.
11. The optimization of cantilever beam is shown in Fig. 5.2 Section 5.2, and then analyzed in next several sections. How to model the beam is defined using other complicated lattice structure or cellular structures, like reference Aamer Nazir, Ahmed Gohar, Shang-Chih Lin, Jeng-Ywan Jeng, "Flexural properties of periodic lattice structured lightweight cantilever beams fabricated using additive manufacturing: experimental and finite element methods", 3D Printing and Additive Manufacturing, 29 Jul 2022.
12. Hip implant was employed as an example to evaluate the case application of the proposed FRep model. How to model and optimization of the lattice structure of hip implant as shown in the paper, Ref: Kalayu Mekonen Abat, Aamer Nazir, and **Jeng-Ywan Jeng,** "Design, Optimization and Selective Laser Melting of Vin Tiles Cellular Structure-Based Hip implant", *The International Journal of Advanced Manufacturing Technology* (2021) 112:2037–2050.

Provisional Recommendation

X *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*