FACULTY OF INFORMATION TECHNOLOGY CTU IN PRAGUE

Supervisor's statement of a final thesis

Supervisor:	Mgr. Petr Šimánek
Student:	Bc. František Koutenský
Thesis title:	Improving neural cellular automata by incorporating physical dynamics
Branch / specialization:	Computer Science
Created on:	21 August 2023

Evaluation criteria

1. Fulfillment of the assignment

▸ [1] **assignment fulfilled**
[2] assignment fulfilled with minor objections
[3] assignment fulfilled with major objections
[4] assignment not fulfilled

The student met all the assignments, the student did much more development and experiments than expected. These additional experiments helped to get much better understanding of the problem at hand and improved the solutions provided. The objectives were correctly formulated and a thorough discussion of the results was provided.

2. Main written part 95 /100 (A)

The student succeeded in compiling a very diverse background necessary for the thesis results. The chapters on cellular automata, neural networks, neural cellular automata, and reaction-diffusion equations are well-written and comprehensible. Together these topics lead to a completely new method that is presented in this work called PINCA (physics-informed neural cellular automata). The section Current Work could be a bit more well structured, and some experiments and their setups could be explained more clearly. The thesis is factually correct, formal notations are also used correctly, and there is a standard number of errors. When using abbreviations, it is standard to use them without the full words after the first use. All the software was used correctly with according to the licences.

3. Non-written part, attachments 99 /100 (A)

The code is well-written, it follows standards used in development of complicated deep neural network models. Experiments are repeatable.

4. Evaluation of results, publication outputs and awards 99 /100 (A)

The core part of the thesis is the PINCA method, which is completely new and combines two very hot fields in AI - Neural Cellular Automata and Physics-Informed Neural Networks. The results are novel and could open new and exciting ways how to study the development of natural systems (e.g. in synthetic biology, ecology, and physics). We are currently preparing paper with the results.

5. Activity of the student

▸ [1] **excellent activity**
[2] very good activity
[3] average activity
[4] weaker, but still sufficient activity
[5] insufficient activity

The student had to first understand many diverse fields, like CA, non-standard deep neural networks, and most of all reaction-diffusion partial differential equations and their numerical solution. The student showed excellent activity and was very eager to learn these new fields. We consulted often and the student was very punctual and was well prepared. It was a joy to work with such a talented and motivated student.

6. Self-reliance of the student

▸ [1] **excellent self-reliance**
[2] very good self-reliance
[3] average self-reliance
[4] weaker, but still sufficient self-reliance
[5] insufficient self-reliance

The student was able to come up with new ideas, experiments, and solutions to all the (many, indeed) issues that appeared in this novel approach to a difficult problem.

The overall evaluation 99 /100 (A)

The student had to understand a very difficult topic, come up with a solution to many problems and conduct many complex experiments. All these steps were necessary to develop and test this new and exciting method called PINCA. And the student did all these steps with great enthusiasm, determination, and patience. The resulting method could be applied in various fields (e.g. in texture design in synthetic biology, meteorology and ecology) and could allow simpler data-driven discoveries of governing equations.

Instructions

Fulfillment of the assignment

Assess whether the submitted FT defines the objectives sufficiently and in line with the assignment; whether the objectives are formulated correctly and fulfilled sufficiently. In the comment, specify the points of the assignment that have not been met, assess the severity, impact, and, if appropriate, also the cause of the deficiencies. If the assignment differs substantially from the standards for the FT or if the student has developed the FT beyond the assignment, describe the way it got reflected on the quality of the assignment's fulfilment and the way it affected your final evaluation.

Main written part

Evaluate whether the extent of the FT is adequate to its content and scope: are all the parts of the FT contentful and necessary? Next, consider whether the submitted FT is actually correct – are there factual errors or inaccuracies?

Evaluate the logical structure of the FT, the thematic flow between chapters and whether the text is comprehensible to the reader. Assess whether the formal notations in the FT are used correctly. Assess the typographic and language aspects of the FT, follow the Dean's Directive No. 52/2021, Art. 3.

Evaluate whether the relevant sources are properly used, quoted and cited. Verify that all quotes are properly distinguished from the results achieved in the FT, thus, that the citation ethics has not been violated and that the citations are complete and in accordance with citation practices and standards. Finally, evaluate whether the software and other copyrighted works have been used in accordance with their license terms.

Non-written part, attachments

Depending on the nature of the FT, comment on the non-written part of the thesis. For example: SW work – the overall quality of the program. Is the technology used (from the development to deployment) suitable and adequate? HW – functional sample. Evaluate the technology and tools used. Research and experimental work – repeatability of the experiment.

Evaluation of results, publication outputs and awards

Depending on the nature of the thesis, estimate whether the thesis results could be deployed in practice; alternatively, evaluate whether the results of the FT extend the already published/known results or whether they bring in completely new findings.

Activity of the student

From your experience with the course of the work on the thesis and its outcome, review the student's activity while working on the thesis, his/her punctuality when meeting the deadlines and whether he/she consulted you as he/she went along and also, whether he/she was well prepared for these consultations.

Self-reliance of the student

From your experience with the course of the work on the thesis and its outcome, assess the student's ability to develop independent creative work.

The overall evaluation

Summarize which of the aspects of the FT affected your grading process the most. The overall grade does not need to be an arithmetic mean (or other value) calculated from the evaluation in the previous criteria. Generally, a well-fulfilled assignment is assessed by grade A.