

Jury Member Report – Doctor of Philosophy thesis.


Name of Candidate: Valentin Khrukov

PhD Program: Computational and Data Science and Engineering

Title of Thesis: Geometrical methods in machine learning and tensor analysis

Supervisor: Professor Ivan Oseledets, Skoltech

Name of the Reviewer: M. Alex O. Vasilescu

<p>I confirm the absence of any conflict of interest</p> <p>(Alternatively, Reviewer can formulate a possible conflict)</p>	<p>Signature:</p>  <p>Date: 7-12-2020</p>
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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 PhD dissertation of Valentin Khrulkov addresses important problems in machine learning and aims to achieve a better understanding of the universality and expressivity of neural networks by taking advantage of the assets of algebraic and differential geometry, tensor algebra, and hyperbolic geometry. The dissertation provides theoretical and practical results in deep learning and numerical optimization. The following contributions were made

1. The dissertation asserts that RNNs are equivalent to TensorTrain decomposition.
2. RNNs with ReLU nonlinearities are evaluated on a grid of points to demonstrate their expressivity and compared with shallow networks.
3. The validity of generative models are ascertained by comparing the topology of the manifold on which the resulting generative data lies versus the manifold on which real data lies. The manifold is reconstructed from simplicial complexes, and comparison between topologies is based on persistent morphology. A new metric is also defined, the Geometry Score.
4. The identification of data taxonomies is addressed by embeddings data in hyperbolic space, a continuous analogue to discrete trees. Visual datasets were evaluated if they contain a hyperbolic structure, and standard pipelines for few-shot learning and re-identification tasks were modified to incorporate hyperbolic geometry approach.

Scientific hypotheses are validated and benchmarked on multiple datasets, and the supporting code is provided on GitHub. The research is novel and has resulted in publications at ICLR'18 and ICLR'19.

Overall, the thesis' logical structure and clarity is adequate. Detailed comments are attached.

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