STRUCTURAL INJECTIONS INTO CONVOLUTIONAL NEURAL OPERATORS FOR ROBUST AND ACCURATE PDE-LEARNING

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Despite success stories in traditional machine-learning (ML) settings such as image classification and object detection, convolutional neural-networks (CNN) have seen limited application for retrieving solution operators of partial differential equations (PDEs). One notable adaptation of CNN in this context [Rao+23] proposes the novel convolutional neural operators (CNOs) architecture, achieving admirable results on various well-studied sample PDEs under several comparisons conditions.

This master-thesis shall primarily extend the CNO architecture through structural enrichment of its underlying model, in particular, the injection of established solutions in other branches of ML such as the Transformer architecture [Vas+23], representative of the attention mechanism, shall be studied to determine adaptability and flexibility of CNO, as well as to further improve its performance. The »benchmarking suite« as proposed by the authors of CNO could also be studied to determine its adequacy in gauging both the accuracy and robustness of operator-learning algorithms in the backdrop of PDE-solving: new sample PDEs models could be added, training conditions and hyper-parameters modified, and performance comparison criteria extended.

The programming component of this thesis is executed in the `python` programming language using various external Deep Learning (DL) libraries. The theoretical work pertains to PDE analysis, continuous structure preservation, as well as robustness and accuracy benchmarking of solution operators for PDE-learning.

This project, conducted under the supervision of Prof. Dr. S. Mishra, is executed within the framework of a Master-Thesis under the catalogue identifier `401-4990-01L` at ETH Zürich. Bogdan Raonić is the project advisor and primary correspondent. The project is scheduled to commence on **04.12.2023**, with a nonnegotiable duration of six (**6**) months and the following projected timeline of major milestones:

Activities	Duration ($\times$weeks)
Initial planning; project structuring	3
Literature survey; ML hardware lab setup	3
Inspection and trial run of existing libraries	3
Initial coding and testing	3
Theoretical formulation; bulk implementation work	6
Benchmarking; results collection	2
Final code review; thesis drafting	4

References

1. Raonić, B. *et al. Convolutional Neural Operators for robust and accurate learning of PDEs* 2023. arXiv: 2302.01178 [cs.LG].
2. Vaswani, A. *et al. Attention Is All You Need* 2023. arXiv: 1706.03762 [cs.CL].