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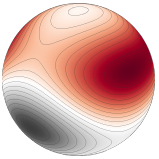
Interdisciplinary Center
for Scientific Computing



Organizational Meeting
Seminar: Mathematical Machine Learning

Summer Semester 2025

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General

- Language: English
- Intended for Master students

Concept of the Seminar

- Read and analyze scientific papers.
- Many-to-Many Role-Playing Format from https://colinraffel.com/blog/role-playing-seminar.html:
- One paper per meeting.
- Take a specific role.
- Discuss the paper together.

Roles: Author

Assume that you are the author of the paper. Present your work. Motivate your research and present your results. Keep in mind that you only have 5 minutes, so focus on the main points. Split up the paper with your partner so that you do not repeat each other.

Roles: Reviewer

Assume that the paper has not been published yet and is currently submitted to a top conference where you've been assigned as a peer reviewer. Complete a full review of the paper answering all prompts of the official review form of the top venue in this research area, e.g. https://www.jmlr.org/reviewer-guide.html. This includes recommending whether to accept or reject the paper.

Roles: Archaeologist

Some time in the future: This paper was found buried under ground in the desert. You're an archaeologist who must determine where this paper sits in the context of previous and subsequent work. Find and report on one older paper cited within the current paper that substantially influenced the current paper and one newer paper that cites this current paper.

Roles: Hacker

You're a hacker who needs a demo of this paper ASAP. Implement a small part or simplified version of the main algorithm in the paper on a small dataset or toy problem. Prepare to share the core code of the algorithm to the class and demo your implementation. Do not simply download and run an existing implementation – though you are welcome to use (and give credit to) an existing implementation for "backbone" code.

Roles: Private Investigator

You are a detective who needs to run a background check on the paper's authors. Where have they worked? What did they study? What previous projects might have led them to working on this one? What motivated them to work on this project? Feel free to contact the authors, but remember to be courteous, polite, and on-topic.

Grading

- Attending all meetings.
- Participation in class
  - In the beginning every person gives a 5 minute report from their role perspective.
  - Afterwards we have a scientific discussion of the paper.

Papers

1. Introduction to Operator Learning (focus on Section 1 and 2)
   Nikola B. Kovachki, Samuel Lanthaler, and Andrew M. Stuart. *Operator Learning: Algorithms and Analysis*. 2024. arXiv: 2402.15715 [cs.LG]. URL: https://arxiv.org/abs/2402.15715

2. DeepONet
   Lu Lu et al. "Learning nonlinear operators via DeepONet based on the universal approximation theorem of operators". In: *Nature machine intelligence* 3.3 (2021), pp. 218–229

3. PCA-Net
   Kaushik Bhattacharya et al. "Model reduction and neural networks for parametric PDEs". In: *The SMAI journal of computational mathematics* 7 (2021), pp. 121–157

4. Fourier Neural Operator (FNO)
   Zongyi Li et al. *Fourier Neural Operator for Parametric Partial Differential Equations*. 2021. arXiv: 2010.08895 [cs.LG]. URL: https://arxiv.org/abs/2010.08895

5. Cost-Accuracy Trade-Off (focus on Section 4 and 5)
   Maarten V. de Hoop et al. *The Cost-Accuracy Trade-Off In Operator Learning With Neural Networks*. 2022. arXiv: 2203.13181 [math.NA]. URL: https://arxiv.org/abs/2203.13181

Timeline

- Today: Distribution of roles
  - Accepting a role is the binding registration for the seminar.
- Starting in April: 5 meetings à 90 minutes
- weekday and time:
  Wed. 14:15-15:45 (23.04., 07.05., 21.05., 04.06., 18.06.)
- seminar room 10, Mathematikon

Assigning Roles

	Paper 1	Paper 2	Paper 3	Paper 4	Paper 5
Author	1	9	7	5	3
Author	2	4	6	8	10
Reviewer	3	1	9	7	5
Reviewer	4	6	8	10	2
Archaeologist	5	3	1	9	7
Archaeologist	6	8	10	2	4
Hacker	7	5	3	1	9
Hacker	8	10	2	4	6
Private Investigator	9	7	5	3	1
Private Investigator	10	2	4	6	8

What's next?

- Resources are online: https://scoop.iwr.uni-heidelberg.de/teaching/2025ss/seminar-mathematical-machine-learning/
- These slides will be shared on the website.

Questions?