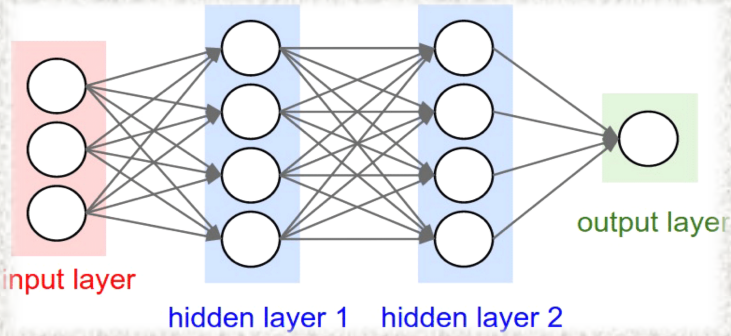
Workshop on Mathematical Machine Learning and Application

December 14-16, 2020



Workshop Theme:

- *Math for Machine Learning*
- *Machine Learning for Math*

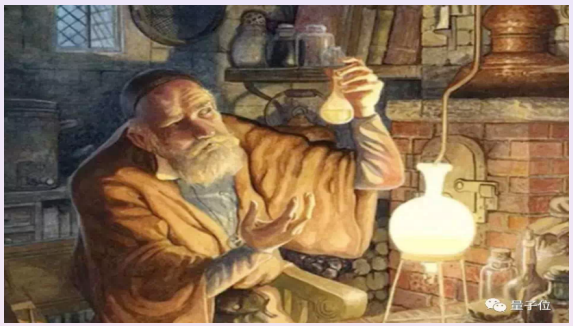
Click on Q&A and type in all your questions during/after each talk

Deep Learning: Great success

- Computer vision
  - Classification, detection, segmentation...
  - Medical image processing,
  - Face recognition,
- Reinforcement learning
  - AlphaGo,
  - Automated driving,
- Natural language processing
  - Speech recognition,
  - Machine translation,
- Scientific machine learning

Deep Learning and Mathematics

Deep learning is “alchemy” ?



Mathematics?

- Many areas of mathematics are applicable!
- One example area: numerical partial differential equations
  - Finite element method
  - Multigrid method

Example: Deep Learning and Numerical PDEs

Most commonly used tool in deep learning:

$$\text{ReLU-DNN} \equiv \text{Linear Finite Element (LFE)!}$$

(He, Li, Xu and Zheng 2018)

Most commonly used ReLU-DNN:

$$\text{ReLU-CNN} \approx \text{Multigrid (slightly modified)} = \text{MgNet}$$

(He and Xu 2019)

Nonlinear space and super-approximation:

$$\inf_{v \in V_n^{ReLU}} \|u - v_n\|_{L^2([0,1]^d)} \approx \left(\inf_{v \in V_n^{LFE}} \|u - v_n\|_{L^2([0,1]^d)} \right)^d = \mathcal{O}(n^{-2} \log n)$$

(Siegel and Xu 2020)

Topics covered in the workshop

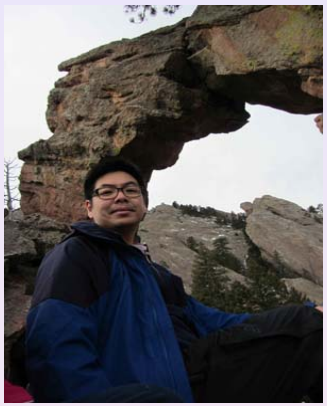
1. Approximation Theory
2. Optimization Algorithms
3. Dimension Reduction, Data Clustering, and Manifold Learning
4. Structure of Neuronal Network and Multiscale models
5. PDE models for machine learning
6. Machine learning for Operators and PDE models
7. Application to Numerical PDEs, Control, and Solvers
8. Graph Theory and Algorithms
9. Inverse Problems and Bayesian Inference
10. Imaging Reconstruction
11. Random Matrix
12. Quantum Computation

Format of the workshop

- 24 Invited Talks
  - 45 minutes for each presentation
  - 15 minutes for Q&A and transition
- Poster presentations (Wednesday evening)
  - Brief introduction in the common zoom room
  - Discussions in individual zoom rooms

Acknowledgement

Local organizing committee


John Harlim


Juncai He


Qingguo Hong


Jonathan Siegel


Jinchao Xu

and many of my Penn State colleagues who graciously agreed to chair sessions

Sponsors

- Penn State Institute for Computational and Data Science (ICDS)
- NSF DMS-2020623 — but not used due to the online format

Technical support

- Penn State IT for webinar sessions.

Thank you
for your participation!