



Conference on the  
Mathematical Theory of  
Deep Neural Networks  
November 4th and 5th, 2021

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# About DeepMath

Recent advances in deep neural networks (DNNs), combined with open, easily-accessible implementations, have made DNNs a powerful, versatile method used widely in both machine learning and neuroscience. These advances in practical results, however, have far outpaced a formal understanding of these networks and their training. The dearth of rigorous analysis for these techniques limits their usefulness in addressing scientific questions and, more broadly, hinders systematic design of the next generation of networks. Recently, long-past-due theoretical results have begun to emerge from researchers in a number of fields. The purpose of this conference is to give visibility to these results, and those that will follow in their wake, to shed light on the properties of large, adaptive, distributed learning architectures, and to revolutionize our understanding of these systems.

# Important Information

- **The conference venue** The focal point of the event is our virtual conference hall, which you can access at <https://gather.town/app/uzoQ1oQU9VRZr4gR/DeepMath%202021> (log in with the same email you used to register for the conference).
- **Posters.** The poster sessions are at 3pm-5pm (15:00-17:00) EST on Thursday and 12:25pm-1:45pm (12:25-13:45) EST on Friday. Poster presenters are asked to be at their posters for both sessions if possible.
- **Best poster voting:** We are crowd-sourcing votes for the DeepMath 2021 best poster. Please vote for your favorite poster at <https://forms.gle/3wafV8PtF2QxDSJC6>.

Questions / Comments / Concerns? Contact one of the organizers in Gather, or email [deep-math.conference@gmail.com](mailto:deep-math.conference@gmail.com).

# Timetable

## Thursday, Nov 4

PT	ET	CET		
07:00 - 07:10	10:00- 10:10	15:00 - 15:10	Opening Remarks	
07:15 - 08:15	10:15 - 11:15	15:15 - 16:15	<b>Stephane Mallat</b>	Deep Network Concentration
08:15 - 08:35	11:15 - 11:35	16:15 - 16:35	Contributed Talk: <b>Shanel SG Gauthier</b>	Parametric Scattering Networks
08:35 - 9:00	11:35 - 12:00	16:35 - 17:00	Open Discussion	
09:00 - 09:20	12:00 -12:20	17:00 - 17:20	Break	
09:20 - 10:20	12:20 - 13:20	17:20 - 18:20	<b>Aarti Singh</b>	Local Signal Adaptivity: Provable Feature Learning in Neural Networks Beyond Kernels
10:20 - 10:40	13:20 - 13:40	18:20 - 18:40	Contributed Talk: <b>Blake Bordelon</b>	SGD on Structured Data: Stability and Optimal Batch Size
10:40 - 11:00	13:40 - 14:00	18:40 - 19:00	Contributed Talk: <b>Zhihui Zhu</b>	A Geometric Analysis of Neural Collapse with Unconstrained Features
11:00 - 12:00	14:00 - 15:00	19:00 - 20:00	Open Discussion	
12:00 - 14:00	15:00 - 17:00	20:00 - 22:00	Poster Session 1 / Lunch	
14:00 - 14:40	17:00 - 17:40	22:00 - 22:40	<b>Tolga Ergen &amp; Mert Pilanci</b>	Best Poster 2020 Update
14:40 - 15:40	17:40 - 18:40	22:40 - 23:40	<b>Rebecca Willet</b>	Auto-differentiable Ensemble Kalman Filters
15:45	18:45	23:40	Socializing / Happy Hour	

## Friday, Nov 5

PT	ET	CET		
06:00 - 07:00	09:00 - 10:00	14:00 - 15:00	Socializing / Breakfast	
07:00 - 08:00	10:00 - 11:00	15:00 - 16:00	<b>Caroline Uhler</b>	Autoencoders and Causality in the Light of Drug Repurposing for COVID-19
08:00 - 09:00	11:00 - 12:00	16:00 - 17:00	<b>Yannis Kevrekidis</b>	Learning emergent PDEs in emergent spaces
08:00 - 08:20	12:00 - 12:20	17:00 - 17:20	Contributed Talk: <b>Bruno Loureiro</b>	Exactly solvable models for learning with realistic data
08:25 - 10:45	12:25 - 13:45	17:25 - 18:45	Poster Session 2 / Lunch	
10:50 - 11:50	13:50 - 14:50	18:50 - 19:50	<b>Raman Arora</b>	Understanding algorithmic regularization in deep learning
11:50 - 12:10	14:50 - 15:10	19:50 - 20:10	Contributed Talk: <b>Xingyu Wang</b>	Eliminating Sharp Minima with Truncated Heavy-tailed Noise
12:10 - 12:25	15:10 - 15:25	20:10 - 20:25	Break	
12:25 - 12:45	15:25 - 15:45	20:25 - 20:45	Contributed Talk: Maria Refinetti	The dynamics of feature learning with shallow, non-linear auto-encoders
12:45 - 13:45	15:45 - 16:45	20:45 - 21:45	<b>Kamalika Chaudhuri</b>	Challenges in Reliable Machine Learning
13:45 - 14:00	16:45 - 17:00	21:45 - 22:00	Closing Remarks	
14:00	17:00	22:00	Socializing / Happy Hour	

# List of Posters

## List of Poster Presentations

### **ID 1: Exact marginal prior distributions of finite Bayesian neural networks**

Jacob A. Zavatone-Veth; Cengiz Pehlevan  
*Harvard University*

### **ID 2: Stability of DCNNs under deformations**

Fabio Nicola; S. Ivan Trapasso  
*Machine Learning Genoa Center; Air Force Office of Scientific Research*

### **ID 3: Detecting Distribution Shift using Neural networks**

Xiuyuan Cheng; Alexander Cloninger; Yao Xie  
*Duke University; UC San Diego; Georgia Tech*

### **ID 4: Learning Gaussian Mixtures with Generalised Linear Models : Precise Asymptotics in High-dimension**

Bruno Loureiro, Gabriele Sicuro, Cédric Gerbelot, Alessandro Pocco, Florent Krzakala and Lenka Zdeborova  
*EPFL; King's College; ENS*

### **ID 5: Global optimal beyond two layers: training deep ReLU networks via convex programs**

Tolga Ergen; Mert Pilanci  
*Stanford University*

### **ID 6: Revealing the structure of deep neural networks via convex duality**

Tolga Ergen; Mert Pilanci  
*Stanford University*

### **ID 7: Shifted GPs capture feature learning effects in finite CNNs**

Gadi Naveh; Zohar Ringel  
*The Hebrew University of Jerusalem, Israel*

### **ID 8: Stochastic Gradients on Structured Features: Stability and Optimal Batch Size**

Blake Bordelon; Cengiz Pehlevan  
*Harvard University*

### **ID 9: A Greedy Algorithm for Quantizing Neural Networks**

Rayan Saab, Jinjie Zhang, Eric Lybrand  
*UC San Diego*

**ID 10: The Separation Capacity of Random Neural Networks**

Sjoerd Dirksen, Martin Genzel, Laurent Jacques, Alexander Stollenwerk  
*Utrecht University; UCLouvain*

**ID 11: Probing transfer learning with a model of synthetic correlated datasets**

Federica Gerace, Luca Saglietti, Stefano Sarao Mannelli, Andrew Saxe, Lenka Zdeborova  
*EPFL; UCL*

**ID 12: Learning curves of generic features maps for realistic datasets with a teacher-student model**

Bruno Loureiro, Cédric Gerbelot, Hugo Cui, Sebastian Goldt, Florent Krzakala, Marc Mézard, Lenka Zdeborová  
*EPFL; ENS; SISSA*

**ID 13: Piece-wise Linear Solutions of SGD for Wide ReLU Networks**

Alexander Shevchenko; Vyacheslav Kungurtsev; Marco Mondelli  
*IST Austria; CTU Prague*

**ID 14: Optimal coding level depends on task in cerebellar networks**

Marjorie Xie, Samuel P. Muscinelli, Kameron Decker Harris, Ashok Litwin-Kumar  
*Columbia University; Western Washington University*

**ID 15: Out-of-Distribution Generalization in Kernel Regression**

Abdulkadir Canatar; Blake Bordelon; Cengiz Pehlevan  
*Harvard University*

**ID 16: Deep Networks Provably Classify Data on Curves**

Tingran Wang; Sam Buchanan; Dar Gilboa; John Wright  
*Columbia University; Harvard University*

**ID 17: Parametric Scattering Networks**

Shanel Gauthier; Benjamin Thérien; Laurent Alsène-Racicot; Irina Rish; Eugene Belilovsky; Michael Eickenberg; Guy Wolf  
*Université de Montréal; Concordia University; Mila – Quebec AI Institute; Flatiron Institute; University of Waterloo*

**ID 18: Representation mitosis in wide neural networks**

Diego Doimo; Aldo Glielmo; Sebastian Goldt; Alessandro Laio  
*SISSA*

**ID 19: Sensitivity of Graph Neural Networks to Graph Topology**

Frederik Wenkel\*; Yimeng Min\*; Matthew Hirn; Michael Perlmutter; Guy Wolf  
*Mila; Université de Montréal; Cornell University; Michigan State University; University of California*

**ID 20: Mechanisms Underlying Sequence-to-Sequence Working Memory**

Ian D. Jordan; Piotr Aleksander Sokół; Il Memming Park  
*Stony Brook University*

**ID 21: Neural Collapse in Deep Homogeneous Classifiers Trained with the Square Loss**

Akshay Rangamani; Andrzej Banburski; Tomaso Poggio  
*MIT*

**ID 22: Embedding Principle of Loss Landscape of DNNs**

Yaoyu Zhang\*, Zhongwang Zhang, Tao Luo, Zhi-Qin John Xu\*  
*Shanghai Jiao Tong University*

**ID 23: Eliminating Sharp Minima with Truncated Heavy-tailed Noises**

Xingyu Wang; Sewoong Oh; Chang-Han Rhee  
*Northwestern University; University of Washington*

**ID 24: Origami in N dimensions: How feedforward networks manufacture linear separability**

Christian Keup; Moritz Helias  
*Jülich Research Centre; RWTH Aachen University*

**ID 25: On the Existence of Universal Lottery Tickets**

Rebekka Burkholz; Nilanjana Laha; Rajarshi Mukherjee; Alkis Gotovos  
*CISPA Helmholtz Center for Information Security; Harvard; MIT*