Nima Dehmamy

Research Staff Member, IBM Research

Research Interests

I work on machine learning for science, graph neural networks and optimization. I design ML architectures capable of discovering and encoding physical symmetries. My long-term goal is to transform and automate scientific discovery. I also work on AI for humanities, using it to understand evolution of arts and science, and paradigm shifts.

Education

PhD in Physics, *Boston University, advisor: H.E. Stanley*	2009—2016
Masters in Physics, *Sharif University of Technology, advisor: S. Rohani*	2006—2008
Bachelor in Physics *Sharif University of Technology*	2002—2006

Experience

Research Staff Member IBM Research, Cambridge MA	Apr 2022—Present
Research Assistant Professor, Northwestern University	Aug 2019—Feb 2022
Postdoctoral Fellow, Northeastern University	Jan 2016—Jul 2019
Research Intern, Quantlab LLC. Boston	Jun–Aug 2015
Visitor, Massachusetts Institute of Technology, Senseable City Lab	Sep 2015
GK-12 Fellow (Fenway High School Science Teacher's Assistant)	Jun–Dec 2012

Skills

Theory: Physics • Machine learning • Graph Neural Networks • Optimization • Dynamical Systems
Programming: Python, JavaScript, HTML/CSS, Shell Scripting, C/C++ Arduino

Honors and Awards

- Nature magazine cover (volume 563 (2018)) — 2018
- Nature Physics cover (volume 17 (Feb 2021)) — 2021
- Ranked top 1% among over 30,000 in the national Physics, Mathematics and Computer Science Olympiads in Iran (2nd round) — 2000 and 2001
- "Extraordinary Achievement in Teaching" award BU Physics — 2011
- As "Exceptional Talent" admitted to Master's program in physics at Sharif University — 2006

Publications

Highlights

1. ***Symmetry Teleportation for Accelerated Optimization*** 2022
   Bo Zhao, <u>Nima Dehmamy</u>, Robin Walters, Rose Yu, **NeurIPS 2022, to appear [arXiv:2205.10637]**

2. ***Symmetries, flat minima, and the conserved quantities of gradient flow*** 2022
   Bo Zhao, Iordan Ganev, Robin Walters, Rose Yu, <u>Nima Dehmamy</u> , **In submission [arXiv:2210.17216]**

3. ***Faster Optimization on Sparse Graphs via Neural Reparametrization*** 2022
   Nima Dehmamy, Csaba Both, Jianzhi Long, Rose Yu , **In submission [arXiv:2205.13624]**

4. ***Automatic Symmetry Discovery with Lie Algebra Convolutional Networks*** 2021
   <u>Nima Dehmamy</u>, Robin Walters, Yanchen Liu, Dashun Wang, Rose Yu, **NeurIPS 2021, [arXiv:2109.07103]**

5. ***Understanding the Representation Power of Graph Neural Networks in Learning Graph Topology*** 2019
   <u>Nima Dehmamy</u>, Albert-László Barabási, Rose Yu, **NeurIPS 2019**

6. ***A Structural Transition in Physical Networks*** 2018
   <u>Nima Dehmamy</u>, Soodabeh Milanlouei, Albert-László Barabási, **Nature 563 (7733), 676**

7. ***Understanding the onset of hot streaks across artistic, cultural, and scientific careers*** 2021
   Lu Liu, <u>Nima Dehmamy</u>, Jillian Chown, C. Lee Giles, Dashun Wang, **Nature Communications volume 12, 5392 (2021) [arXiv:2103.01256]**

8. ***Isotopy and Energy of Physical Networks*** 2020
   Yanchen Liu, <u>Nima Dehmamy</u>, Albert-László Barabási, **Nature Physics 17 (2), 216-222**

9. ***On the universality of inner black hole mechanics and higher curvature gravity*** 2013
   Alejandra Castro, <u>Nima Dehmami</u>, Gaston Giribet, David Kastor, **JHEP 1307 2013 164 arXiv:1304.1696 [hep-th]**

Other Publications

1. ***Systemic stress test model for shared portfolio networks*** 2021
   Irena Vodenska, <u>Nima Dehmamy</u>, Alexander P Becker, Sergey Buldyrev, Shlomo Havlin, **Scientific Reports 11 (3358)**

2. ***3D Topology Transformation with Generative Adversarial Networks*** 2020
   Luca Stornaiuolo, Mauro Martino, Albert-László Barabási, <u>Nima Dehmamy</u>,
   Proceedings of ICCC'20

3. ***Direct Estimation of Weights and Efficient Training of Deep Neural Networks without SGD*** 2018
   <u>Nima Dehmamy</u>, Neda Rohani, Aggelos Katsaggelos, **Proceedings of ICASSP 2019**

4. ***Crises and Physical Phases of a Bipartite Market Model*** 2016
   Nima Dehmamy, Sergey Buldyrev, Shlomo Havlin, H Eugene Stanley, Irena Vodenska,
   [arXiv:1609.05939]

5. ***First Principles and Effective Theory Approaches to Dynamics of Complex Networks*** 2016
   <u>Nima Dehmamy</u> (PhD Dissertation),

6. ***Arbitrary Degree Distribution and High Clustering from a Local Geometric Network Growth Model*** 2015
   <u>Nima Dehmamy</u>, Navid Dianati (equal contribution), **[arXiv:1501.03543]**

7. ***Classical Mechanics of Economic Networks*** 2014
   <u>Nima Dehmamy</u>, Sergey Buldyrev, Shlomo Havlin, H. Eugene Stanley and Irena Vodenska,
   [arXiv:1410.0104]

Review for Journals and Conferences

- AAAI 2021, 2022
- NeurIPS workshop on Interpretable Inductive Biases and Physically Structured Learning 2020
- Nature Communications
- Physical Review Letters
- Physical Review E
- Physical Review Research
- Nature Scientific Reports
- Nature Communications Physics
- Nature Machine Intelligence
- Social Network Analysis and Mining (SNAM)
- IEEE Transactions on Signal Processing
- Network Neuroscience
- Physica A
- NetSciX 2020, Tokyo, Japan, 2019
- Northeast Regional Conference on Complex Systems, Binghampton, NY, 2019
- Complenet 2018, Scientific Committee

Conferences, Presentations, Posters and Summer Schools

Presentations

- **Learning Network Structure Using graph Convolutional Networks**
  DATA Lab, Khoury College of CS, Northeastern University, Boston, MA, USA — Jul 2020
  RIKEN AIP, Tokyo, Japan — Jan 2020
  NetSciX 2020 — Jan 2020
- **Topological Characterization of Meta-stable States in Weakly Non-linear Diffusion Processes on Networks**, NetSci 2019 — Jun 2019

- **A Structural Transition in Physical Networks** — Feb 2019
  Harvard Medical School, Channing Division of Network medicine,
- **Perturbed Linear Dynamics on Networks and Surprises of Force-directed Layouts**
  NICO, Northwestern University, Evanston, IL — Jan 2019
- **Utilizing hierarchy to approximate dynamics on networks** — Jul 2018
  ICCS 2018, Cambridge, MA
- **Forgoing SGD: Approximating layer weights directly from training data in deep neural networks** — Jun 2018
  IBM Watson Research Lab, Cambridge, MA
- **Hierarchy and Time Scales: What Deep Learning and Network Science can learn from each other** — Apr 2018
  Physics Department, Michigan State University, East Lansing, MI
- **Optimization Problems on Networks, and What Deep Learning and Network Science can learn from each other** — Apr 2018
  Broad Institute of MIT and Harvard, Cambridge, MA
- **The Power of Hierarchy: What Deep Learning and Network Science can learn from each other** — Apr 2018
  Kellogg School of Management, Northwestern University, Evanston, IL
- **Structural Phase Transition in Physical Networks Embedded in 3D**
  Complenet'18, Boston, MA — Mar 2018
  Dynamics Days 2018, Denver, CO — Jan 2018
- **Properties of Networks of Local Interaction** — Sep 2015
  CCS2015
- **Empirically validated model of stock return dynamics** — Sep 2015
  CCS2015
- **A Systemic Stress Test Model in Bank-Asset Networks** — Sep 2015
  CCS2015
- **Cities as attractive potential: Networks over cities from physical interactions** — Jun 2015
  MIT Senseable City Lab
- **Properties of Networks of Interacting Stochastic Agents** — May 2015
  BU Departmental Seminar
- **Landau-Ginzburg-type Effective Lagrangians for Dynamical Networks** — Jan 2015
  Condensed Matter Theory Group Meeting
- **From Classical Fields to Networks of Arbitrary Degree Distribution and High Clustering**
  Condensed Matter Theory Seminar — Jan 2015
- **Cities as Attractive Potentials: Modeling City Social Networks as Physical Interactions**
  MIT HumNet Group seminar — Feb 2015
- **A Systemic Stress Test Model in Bank-Asset Networks** — Dec 2014
  MIT Media Labs, The Consortium for Systemic Risk Analytics and SYRTO,
- **Structure of News Sentiment Time Series** — Jun 2014
  NetSci, Presentation in the Net-O-Nets Satellite,

Posters

- **Understanding the Representation Power of Graph Neural Networks in Learning Graph Topology**
  LANL 3d Physics Informed Machine Learning — Jan 2020

IPAM Workshop: Interpretable Learning in Physical Sciences   Oct 2019
NeurIPS 2019 (presented by Rose Yu)   Dec 2019
- ***Topological properties of Network Embeddings***   Jun 2019
  NetSci 2019
- ***Direct Estimation of Weights and Efficient Training of Deep Neural Networks without SGD***   Apr 2019
  ICASSP 2019
- ***Vox2Net: From 3D Shapes to Network Sculptures***   Dec 2018
  NIPS Creativity Workshop
- ***Structural Phase Transition in Physical Networks***   Jan 2018
  Dynamics Days 2018
- ***Physical Phases of Three Dimensional Networks***   Jun 2017
  NetSci
- ***Arbitrary degree distribution and high clustering from a local geometric network growth model***   Jun 2015
  NetSci, Zaragoza, Spain
- ***Landau-Ginzburg Network Dynamics and Stability Analysis***   Jan 2015
  Dynamics Days XXIV, Nima Dehmamy.
- ***Analytically Solvable Network Growth Model***   Jan 2015
  Dynamics Days XXIV, Navid Dianati, Nima Dehmamy.
- ***A Dynamical Model of Systemic Risk in Bank-Asset Networks***   Jun 2014
  NetSci, Nima Dehmamy, Sergey Buldyrev, Shlomo Havlin, H. Eugene Stanley and Irena Vodenska.
- ***Communal Peer Selection and Scale-free Networks***   Jun 2014
  NetSci, Navid Dianati, Nima Dehmamy.

Lectures

- Mathematical Physics, 4 lectures at IPM, Tehran, Iran   Fall 2007
  on Gauge theory, Path integrals, Moyal Deformation General Relativity and Supersymmetry
- Classical perturbation theory   Spring 2006
  invited lecturer for Intermediate Classical Mechanics class
- Introductory Lecture on String Theory   Aug 2006
  at High School for Exceptional Talents in Shahr-e-Rey
- Renormalization and Effective Lagrangian by J. Polchinski   Spring 2006
  for Quantum Field Theory II

Conferences and Workshops

- NetSciX Tokyo, Japan   Jan 2020
- LANL 3d Physics Informed Machine Learning Santa Fe, NM, USA   Jan 2020
- IPAM Workshop II: Interpretable Learning in Physical Sciences UCLA   Oct 2019
- NetSci'19 Burlington, VT, USA   Jun 2019
- KITP At the Crossroad of Physics and Machine Learning Santa Barabara, CA, USA   Feb 2019
- Complenet'18 Boston, MA, USA   Mar 2018
- Dynamics Days Denver, CO, USA   Jan 2018
- NetSci (Network Science Conference) Indianapolis, IN, USA   Jun 2017
- APS March Meeting (American Physical Society) New Orleans, LA, USA   Mar 2017
- CCS2015 (Conference on Complex Systems) Tempe, AZ, USA   Sep 2015
- Dynamics Days XXIV Houston, TX, USA   Jan 2015
- NetSci Berkeley, CA, USA   Jun 2014
- Simons Workshop in Mathematics and Physics   Aug 2010
- Emergent Gravity, SISSA, Trieste, Italy   Mar 2007
- Neuroscience, IPM, Tehran, Iran   Jun 2005

Coding, Robotics and Electronics Projects

1. **Vox2Net: From 3D shapes to Networks** (2018) We designed a 3D pix2pix GAN and taught it to

convert 3D shapes to networks. The output is further processed with the 3D-ELI algorithm (below) to create a realistic 3D network out of a 3D shape. (git in preparation)

2. **DMN: Density Matrix Network** (2017) A pre-trained neural network using a supervised PCA method, which can replace conventional ConvNet or fully connected layers. Based on our paper (arxiv.org/abs/1703.04757) (github: github.com/nimadehmamy/DMN.git)

3. **3D-ELI-FUEL: Simulation code for laying out networks in 3D space** (2017) The algorithm curves links and optimizes link length. Coded in Python, using TensorFlow to run on the GPU. (github: github.com/nimadehmamy/3D-ELI-FUEL)

4. **3dvis: A Visualization Tool for networks embedded in 3D space** (2016) Purely client-side javascript, using Three.js (github: github.com/nimadehmamy/3dviz)

5. **Nomadnet: A Project visualization and management tool** (2016) In JavaScript, used for managing interactions and progress of projects one is involved in. Will link to Slack and hopefully Rocket.chat soon.

6. **"Web-controlled Robotic Arm"** (2016) Using Node.js, webRTC, and Arduino to build a doll controlled over the web

7. **"Internet of Things" projects with Raspberry Pi** (2015) temperature sensing with ADC of ATTiny45 and reporting with I^2C to Raspberry Pi; 2 day project with friend.

8. **Halloween robotic doll "Overly-attached Cyborg"** (2014) with sonic ranging, scouts different angles by turning neck, warns proximal subjects by making eyes glow red and waves arm at them.

9. **LED star with touch control** (2014) ATTiny45 and custom built and coded capacitive touch sensor and wireless charging; with a friend.

10. **Transformer Biped** (2012) car and biped hybrid with 15 micro-servos and driven by Arduino Micro and Adafruit I^2C motor servo shield.

11. **Humanoid Arm** (2003) with 8051 microcontroller with serial interface to Matlab

12. **Object Gatherer** (2003) college team, Amir Kabir University

13. **Fire-fighting pathfinder robot** (2003) Amir Kabir University (no microcontrollers, just TTL logical gates, OP-Amps, FET H-bridges and basic electronics.)

Web

LinkedIn
http://www.linkedin.com/pub/nima-dehmamy/4a/70a/577

Google Scholar
http://scholar.google.com/citations?user=gvHpUtgAAAAJ&hl=en

ResearchGate
http://www.researchgate.net/profile/Nima_Dehmamy