GSH Fall Forum: Applications of Machine Learning Thursday, November 8, 2022				
Start time	**End time**	**Title**	**Speaker**	**Session**
8:30	9:00	Registration, Check-in, Continental Breakfast		
9:00	9:10	**Welcome / Introduction**	Scott Singleton	
9:10	9:40	Keynote: Machine learning in energy applications – current state and future opportunities	Weichang Li, The AI Technology Group Leader at Aramco Americas' Houston Research Center	
9:40	9:45	*Panel setup*		**Best Practices**
9:45	10:45	Panel: Challenges and Best Practices of Deploying Geoscience ML Solutions Moderator: Eduardo Alvarez	Pandu Devarakota, Principal Scientist, Technology Advisor, Shell Sathiya Namasivayam, VP Data & Analytics, TGS Dan Kahn, Sustainability Lead, AWS Dan Piette, CEO, Bluware	**Best Practices**
10:45	11:00	*Networking Break*		
11:00	11:30	Fluid and Transport Properties in Porous Media	Birol Dindoruk, U of H	**Drilling/ Engineering Applications**
11:30	12:00	Estimating Real-Time Pore Pressure at the Bit via Machine Learning Techniques	Matthew Reilly, Hess	**Drilling/ Engineering Applications**
12:00	13:00	*Networking Lunch*		
13:00	13:30	An unsupervised stochastic machine learning approach for well log outlier identification	Ridvan Akkurt, SLB	**Seismic Applications**
13:30	14:00	Seismic Swell Noise Attenuation using Machine Learning	Olga Brusoca, TGS	**Seismic Applications**
14:00	14:30	*Networking Break*		

14:30	15:00	Geophysics In The Cloud: GITC22 Competition Results; Presentation by the winners - Team ThreeAmigos	Eduardo Alvarez, Altay Sansal, Team ThreeAmigos	**Case Studies**
15:00	15:30	Driving Mechanisms for drainage volume and cumulative oil: case studies for the Midland Basin with diffusive time of flight and machine learning	Yuxing Ben, Oxy	
15:30	16:00	Closing Keynote: Neural Scaling Laws and a Way Forward Towards Scalable and Sustainable AI	Anshumali Shrivastava, Rice	
16:00	18:00	*Cocktail Reception*		

Keynote Speaker

Weichang Li leads the AI Technology Group at Aramco Americas' Houston Research Center where he joined in 2015. His current research focuses on developing machine learning and signal processing algorithms/models for geophysics, geoscience and petroleum engineering applications. Prior to Aramco, he had been with ExxonMobil's Corporate Strategic Research lab since 2008 where he led the machine learning team from 2011-2014. Weichang has co-organized the SEG machine learning post-convention workshop from 2018 to 2022, the SIAM Data Mining workshop in Geoscience Applications in 2018, and is the associate editor for Geophysics special section on Machine Learning, and recently IEEE Transaction on Neural Network and Learning Systems special issue on Deep Learning for Earth Sciences and Planetary Geosciences. He has published over 100 papers and 15 patents. Weichang obtained his M.S. (dual) in Electrical Engineering and Computer Sciences, and Ocean Engineering (2002), and Ph.D. in Electrical and Oceanographic Engineering (2006), all from MIT.

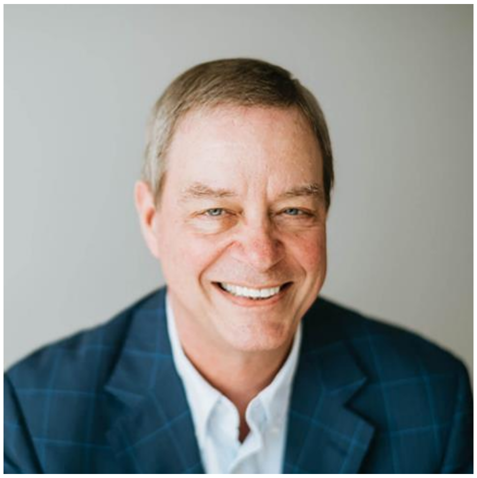
Panel: Challenges and Best Practices of Deploying Geoscience ML Solutions

Sathiya Namasivayam, VP of Data & Analytics, TGS

Sathiya has vast experience for last 25+ years in building Software Products & Data Products in Oil & Gas data domain. Now responsible for Software Engineering & Data Analytics at TGS busy building innovative products with machine learning algorithms & client facing Eco systems. In his spare time, he enjoys traveling with his wife and two daughters.

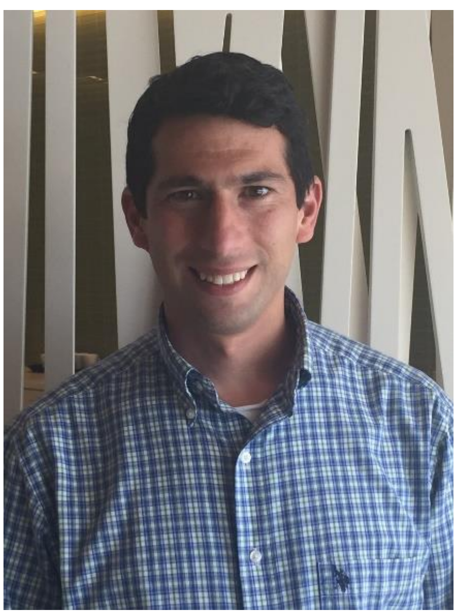
Pandu Devarakota, AI Lead and Principal Science Expert, Shell Global Solutions USA

Bio: Pandu Devarakota is a Principal Science Expert at Shell Global Solutions USA. He joined Shell in 2014 and is currently a member of the global Artificial Intelligence R&D team in Houston. He focusses on developing early-stage proof of concepts using deep learning and AI methods to accelerate AI adoption as part of Shell's artificial intelligence (Shell.ai) strategy. Pandu received his PhD in Signal Processing from the Royal Institute of Technology (KTH) in Stockholm, Sweden, in 2008, and is practitioner of machine learning techniques in solving many real-world problems. He worked as a Research Scientist with Siemens earlier in his career, where he contributed to the development of several computer aided diagnosis solutions for detecting cancer at an early stage. He led a team at Canon that was working on the next generation of GPU-accelerated healthcare IT products.



Dan Piette, Chief Executive Officer, Bluware

Dan Piette joined Bluware in 2018 as CEO. Mr. Piette previously served on the board of Petroleum Geo-Services, a publicly traded marine seismic acquisition company, and President, CEO, and Executive Chairman of TerraSpark Geociences, a seismic data interpretation software technology company. Piette also served on the board and as President and CEO of Object Reservoir and OpenSpirit. Each of these companies were dedicated to delivering new technology to the oil and gas industry and were successfully sold to various oil field service or horizontal software companies. After receiving his Bachelor of Science with honors in Mining Engineering from the University of Wisconsin-Madison in 1980, Piette started his career with Exxon Minerals, working in both hard rock and oil shale projects. He held several executive management positions in the oil and gas industry, including general manager postings in Singapore and Caracas. Piette was a key employee of Landmark Graphics when new 3D seismic interpretation tools were introduced. Additionally, Mr. Piette was instrumental in the introduction of various new technologies to the industry, from gravity gradient data to computer generated mapping and economic analysis.



Dan Kahn, Sr. Lead Technical Program Manager, AWS

Dan Kahn is an innovative geophysicist with 20 years of experience applying cutting-edge technology to unconventional reservoirs and geothermal production. At AWS, he is responsible for driving digital transformation for companies within the energy verticals globally. Helping these companies thrive using innovative AWS and partner solutions that enable operational efficiency, improve productivity and uncover new business models that will accelerate the energy transition. Some of his highlight achievements are Winning the Amazon Shark Tan innovation competition, Selection as Devon’s Innovator of the Year, and recipient of Exxon’s Gold Service Medal.

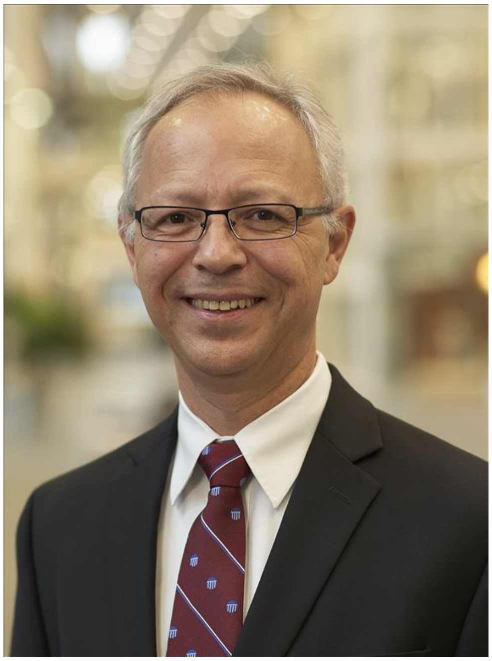
Prediction of Basic Data (Fluid Properties and Relative Permeability) Using Hybrid AI Approaches

Birol Dindoruk, U of H

The current landscape and culture in many organizations are not aligned with the productization and value generation of workflows using AI/ML techniques. Liberation of the software is ongoing, however we are not at the same level when data and algorithms are compared in a production environment. We have a lot of digital "exhaust" when accumulating the necessary data (direct and indirect). We will discuss some of these elements and the structure we need to have in terms of solving problems (or getting the value out of the information).

I will show specific examples of fluid properties and relative permeability data which are used in multi-disciplinary applications, from reservoir evaluation to reservoir performance management and in a broader sense for flow in porous media for various applications. In this session I will focus on various aspects of prediction of such data and how to utilize the physics-based content knowledge along with data-centric approaches:

- Current Landscape and workflows
    - Collection of relevant data
    - When and where to collect the data
    - Metadata
    - Data sharing, security, use → product
    - Quality/Quantity (how do we measure this? "Weight"? Use?)
    - Compatibility
- Deficiencies in both physical and as well as correlative models
    - Seeking for quantitative proxies and their existence
- Final products by examples: Physics augmented/hybrid approaches by examples
- Discussion



Dr. Birol Dindoruk is currently American Association of Drilling Engineers Endowed Professor of Petroleum Engineering at University of Houston, previously he was the Chief Scientist of Reservoir Physics and the Principal Technical Expert of Reservoir Engineering in Shell.

His technical contributions have been acknowledged with many awards during his career, including SPE Lester C. Uren Award (2014), Cedric K. Ferguson Medal (1994), and Distinguished Membership. In 2017, he was elected as a member of the National Academy of Engineering for his significant theoretical and practical contributions to enhanced oil recovery and CO2 sequestration.

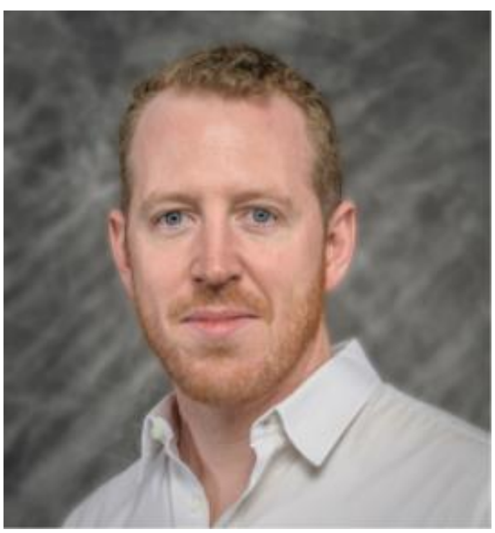
Recently, Dr. Dindoruk has also been working in the area of data analytics, artificial intelligence, and machine learning and focusing on effective incorporation of data sciences into the oil and natural gas industry practices and energy systems. In recent years, he has authored/co-authored various articles for hydrogen, geothermal systems and adsorptive storage.

Dindoruk has 28 years of industrial experience, holds a BSc Degree from Technical University of Istanbul in Petroleum Engineering, MSc Degree from The University of Alabama in petroleum engineering and also a PhD from Stanford University in Petroleum Engineering and Mathematics, and an MBA from University of Houston.

Estimating Real-Time Pore Pressure at the Bit via Machine Learning Techniques

Matt Reilly, John Thurmond, Mike Party, Koda Chovanetz – Hess
Barry Zhang Muhlis Unaldi, Orlando De Jesus – Quantico Energy Solutions

A method is proposed to calculate pore pressure at the bit while drilling using all data typically available in a modern drilling rig. This method utilizes a machine learning approach that can estimate pore pressures with the same or greater accuracy as traditional methods and can do so at the bit in real-time. Traditional pore pressure estimation while drilling utilizes a combination of data sources most of which are detected from sensors placed 100's of feet behind the drill bit (where resistivity, sonic, density etc tools are commonly placed). Furthermore, smoothing algorithms are often used to average the detection data thus increasing the offset from the drill bit to the estimated pore pressure calculation. The result of this is that the pore pressure calculation while drilling is only relevant to the formation that has been penetrated and not being actively drilled. In hole sections where minor pore pressure changes can have significant impact on operational decisions this has significant disadvantages. Whereas traditional methods give an estimate of pore pressure after the well has already experienced a change in pressure this method can calculate pore pressure as the change is occurring. Another benefit of applying a machine learning model to pore pressure calculation while drilling is that the computational time is almost instant and does not require human synthesis and calculation of the data which must then be relayed to the rig.



Matthew Reilly is the Technical Authority for pore pressure and fracture Gradient at Hess Corp. In this role he is responsible and accountable for pore pressure and wellbore stability for Hess' global operating portfolio. Matthew has a broad geoscience background with 15+yrs of industry experience. He has experience in subsalt seismic interpretation, reservoir geomodelling, onshore operations and well planning as well as deep knowledge in pore pressure prediction and real-time calculation. Matthew has worked multiple basins across the world from S.America, Africa, Europe to South East Asia and is currently focused on Hess' Atlantic margin assets and Malaysia. As Technical Authority he also pursues innovation challenges and is particularly focused on AI/ Machine Learning techniques with a goal to defining a step change to the way the industry approaches pore pressure and drilling practices. Matthew hold as MS in Geoscience from Penn State (U.S.A) and a BSc in Geology from University of Durham (U.K.)

An Unsupervised Stochastic Machine Learning Approach for Well Log Outlier Identification

Ridvan Akkurt, Bhuvaneswari Sankaranarayanan, Vanessa Simoes, Hiren Maniar, Per Irgens, Ben Hoffman – Schlumberger
Kevin Fisher – Birch Resources

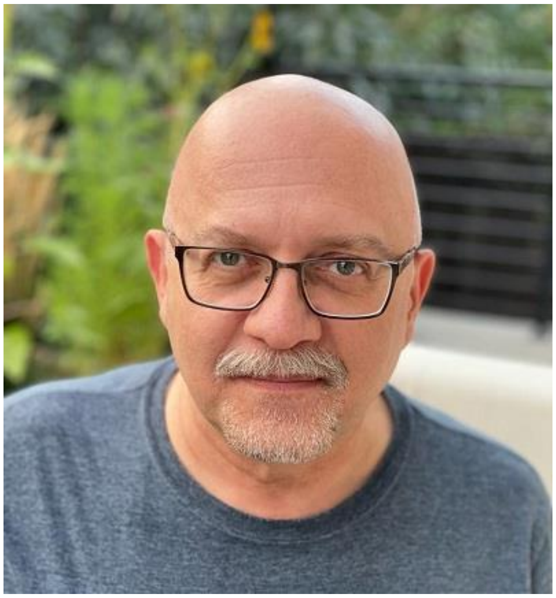
Outlier detection is a critical component of every Log Quality Control workflow and a Machine Learning implementation that is unsupervised and automated must robustly address several challenges. The outlier analysis methodology developed should not only correctly identify truly anomalous data points; but also preserve those that may appear anomalous due to infrequent data representation; or are distanced from the main body of the data or sweep the extremes of accepted measurement ranges. In addition, the workflow must be overall efficient in terms of memory usage/CPU times and provide a metric for uncertainty in the answers.

The outlier detection algorithm presented in this paper is stochastic by design and addresses the above challenges by integrating results from an ensemble-system created from multiple realizations. For each realization, the N wells in a data set are randomly grouped into mini-batches comprised of n wells, where n << N. The One-Class Support Vector Machine (1CSVM) method, choice of which is inspired by the well-known neutron-density crossplot, is run on each group independently to create outlier flags for all the data vectors in the realization. The information from the thus formed ensemble is then used to compute outlier probabilities for each data vector, providing a proxy for uncertainty.

Processing wells in mini-batches minimizes complications from under-representation and allows the retaining of local features. Compared to processing all wells set at once, the stochastic method is quite robust and significantly more efficient in memory and CPU utilization.

A unique feature of our outlier methodology is the weighting of the input data vectors used by the 1CSVM algorithm, based on domain knowledge of petrophysics and measurement physics. This functionality minimizes the mislabeling of isolated data points that represent valid data as outliers.

The outlier detection workflow is automated and requires minimal user input. It is efficient and ideal for unconventional applications where the typical data set contains large volumes of legacy data acquired by multiple logging companies often in severe borehole conditions. It has been tested over the past 3 years on approximately 70 data sets, containing anywhere from tens to hundreds of wells, from different parts of the world in varying geological settings. Continuous improvements made to compensate for limitations discovered during this period have resulted in a time-tested algorithm that is robust and mature.



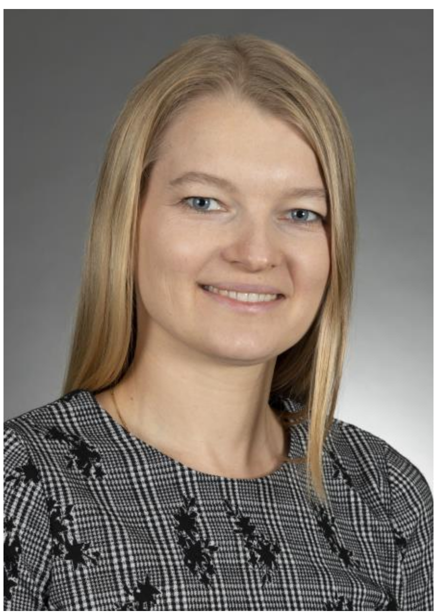
Ridvan Akkurt is a Domain Consulting Petrophysics Advisor in Schlumberger Artificial Intelligence and Analytics Group, based in Denver, CO, USA. He was previously Research Director at Schlumberger-Doll Research in Boston heading the Reservoir Geosciences Department, and Petrophysics Advisor at Schlumberger SIS Headquarters in London. Ridvan began his career in 1983 as a Schlumberger wireline field engineer in Africa, then worked for a number of companies including GSI (Geophysical Service Incorporated), Shell, NUMAR, NMR+, and Saudi Aramco; in international and domestic assignments. He has a BS degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge, USA; and a PhD degree in geophysics from the Colorado School of Mines in Golden, USA. Ridvan has many publications and 20+ US patents, has taught industrial courses, served as Distinguished Lecturer for SPWLA and SPE multiple times, and is a reviewer for industrial journals.

Seismic Swell Noise Attenuation using Machine Learning

Olga Brusova, Sean Poche, Sribharath Kainkaryam, Alejandro Valenciano, TGS

Coherent noise (e.g., swell, SI) attenuation is an early step in the seismic processing workflow. If noise is not reduced, it can contaminate the final seismic image, interfere with the processing algorithms' performance, and affect the quality of amplitude-based attributes. Traditional seismic attenuation methods need parameter tuning and quality control (QC) to obtain clean gathers with minimal effect on the signal. Their results often require laborious QC to check for residual noise or areas with an attenuated signal that needs special attention and parameter fine-tuning. Machine Learning (ML) can potentially solve traditional methods' drawbacks.

Here we share two different ML strategies to approach the denoising problem. The first is a classification algorithm that predicts if seismic gathers were processed optimally. After the classification, traditional methods that use distinct parameterization are applied to different data sections for optimum results. Our work builds upon Bekara and Day (2019), contrasting the efficacy of different classifiers. The second approach avoids conventional denoising methods, employing a deep learning architecture to remove the swell noise from seismic shot gathers. We address the need for labeled training data by combining clean shot gathers (with swell noise removed) with swell noise gathers recorded in the field for a convenient signal vs. noise separation.



Olga Brusova is a QI geophysicist and a data scientist with TGS. She received her M. S. in Geophysics and Ph.D. in Physics from the University of Utah. Now she is pursuing M. S. degree in computer science from Georgia Tech University. Olga started her oil and gas career at BP as a QI geophysicist with specialization in seismic rock properties. She worked on many aspects of reservoir characterization including feasibility studies, inversion, 4d in conventional reservoirs and unconventionals. In 2017 Olga join Anadarko's data analytics team to lead ML QI initiatives where she worked on variety of projects including ML well log processing and prediction, data driven seismic inversion, reservoir model building using deep learning and others. In early 2020 Olga joined TGS and is now working on building deep learning solutions for seismic processing, well log clean up and QC, and others.

Driving Mechanisms for Drainage Volume and Cumulative Oil: Case Studies for the Midland Basin with Diffusive Time of Flight and Machine Learning

Yuxing Ben, Oxy

The Diffusive Time of Flight (DTOF) workflow was used to analyze the completion design, well spacing, and well production for 43 wells completed recently in different landing targets in the Midland Basin. In addition, machine learning was leveraged to identify the key drivers for drainage volume and cumulative oil production after only a short time on production (130 days).

The workflow comprises two steps: (1) The pressures of a group of wells in a similar geological area were measured using downhole gauges. The DTOF workflow (URTeC 5106, 2021) was employed to calculate the drainage volume, surface area, and depletion efficiency. (2) A proprietary algorithm was used to calculate the well spacing and track well sequencing. Two machine learning (ML) models were trained, one with DTOF-estimated drainage volume as the target variable, and the other with cumulative production as the target variable. Well spacing, reservoir fluid properties, completion design, and well sequencing information were included as input variables in the ML models. The key drivers for the drainage volumes and cumulative production were identified by the SHapley Additive exPlanations (SHAP) values of the ML models.

The dataset was high-quality because the bottomhole pressure was measured with a downhole gauge. The ML models are shown to have a reasonable accuracy despite the limited number of wells. Such models can identify the nonlinear relationships between variables represented by the corresponding SHAP values. Proppant concentration is shown to be the key driver for drainage volumes and cumulative oil production for this group of wells. A higher initial water saturation is associated with larger drainage volume but lower cumulative oil production. Compared with completion design, initial water saturation, and landing benches, the well spacing and sequencing play a less significant role in completion efficiency and well production.

The diagnostic workflow based on Diffusive Time of Flight was successfully applied to a group of wells in the Midland Basin. It offers quick analytical results even early in a well’s life and requires few input parameters. In addition, the analysis makes no assumptions on fracture geometry and flow regimes. Combined with machine learning models and SHAP values, this workflow can assist engineers in conducting look-back analyses and making quick decisions about future well planning.

Dr. Yuxing Ben is a reservoir engineer at Occidental, where she develops hybrid physics and data-driven solutions in the subsurface engineering technology group. She was the principal developer of machine learning technology for Anadarko's real-time drilling and hydraulic fracturing platforms. She won the best paper award from URTeC 2019 and was selected as a SPE distinguished lecturer for 2021. Prior to Anadarko, Dr. Ben served as the technical expert for Baker Hughes' hydraulic fracturing software—MFrac. She has developed complex fracture model for Halliburton and was a postdoc at MIT. She has authored more than 30 papers and holds three US patents. She earned a BS in theoretical mechanics at Peking University, and a PhD in chemical engineering from the University of Notre Dame.

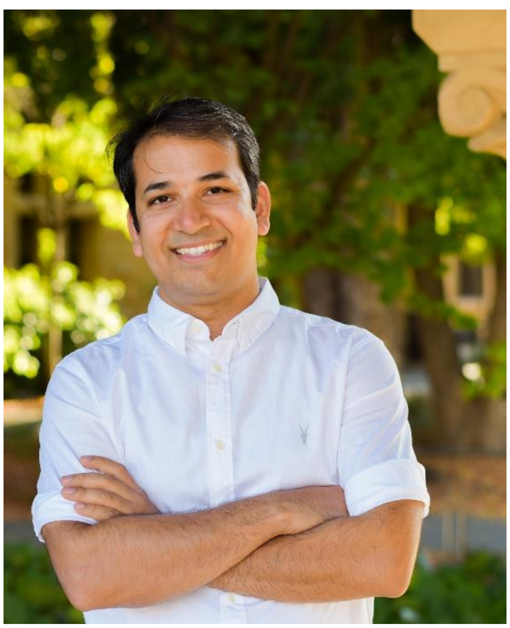
Closing Keynote

Neural Scaling Laws and a Way forward towards Scalable and Sustainable AI.

Anshumali Shrivastava, Rice

Neural Scaling Law informally states that an increase in model size and data automatically improves AI. However, we have reached a point where the growth has reached a tipping end where the cost and energy associated with AI are becoming prohibitive.

This talk will demonstrate the algorithmic progress that can exponentially reduce the compute and carbon footprint of training and inference with neural networks. We will show how data structures, particularly randomized hash tables, can be used to design an efficient "associative memory" that reduces the number of multiplications associated with the training of the neural networks.
Implementation of this algorithm challenges the common knowledge prevailing in the community that specialized processors like GPUs are significantly superior to CPUs for training large neural networks. The resulting algorithm is orders of magnitude cheaper and energy-efficient. Our careful implementations can train billions of parameter recommendations and NLP models on commodity desktop CPUs significantly faster than top-of-the-line A100 GPU clusters, with the same or better accuracies. The same idea can also result in more than 100x cheaper inference.



Anshumali Shrivastava is an associate professor in the computer science department at Rice University. He is also the Founder and CEO of ThirdAI Corp, a company that is democratizing AI to commodity hardware through software innovations. His broad research interests include probabilistic algorithms for resource-frugal deep learning. In 2018, Science news named him one of the Top-10 scientists under 40 to watch. He is a recipient of the National Science Foundation CAREER Award, a Young Investigator Award from the Air Force Office of Scientific Research, a machine learning research award from Amazon, and a Data Science Research Award from Adobe. He has won numerous paper awards, including Best Paper Award at NIPS 2014, MLSys 2022, and Most Reproducible Paper Award at SIGMOD 2019. His work on efficient machine learning technologies on CPUs has been covered by popular press including Wall Street Journal, New York Times, TechCrunch, NDTV, Engadget, Ars technica, etc.