LASCAS 2026 Conference Tutorial Proposal

Organizers and Speakers (Last name, First Name): OGUNFUNMI, Tokunbo and DEB, Manas Submitter email addresses: TOgunfunmi@scu.edu, MDeb@scu.edu

Tutorial Title: Theoretical Foundations and Applications of Generative AI Models

Abstract:

Deep generative models (DGMs) are part of the deep learning model family and are a powerful way to learn any distribution of observed data. Large Language models (LLMs) have shown a remarkable ability to "converse" with humans in a natural language across myriad topics. From generating realistic images and audio to creating human-like text, Generative AI (GAI) is transforming industries. This tutorial dives deep into the theoretical underpinnings of the latest Generative AI models and architectures. We explore the probabilistic, information theoretic and optimization foundations that power models like:

- Generative Adversarial Networks (GANs)

- VAE (Variational Autoencoders)

- Autoregressive models like Generative Pre-trained Transformers (GPT) •
Diffusion models, etc.

Motivation and Focus:
This tutorial is important to the CAS community in general and the LASCAS community in particular because these DGM and LLM models are applicable for solving several problems in machine learning, deep learning and various applications.

Syllabus: Contents of the tutorial

- Review of probability theory, information theory and inference

- Basics of Generative AI (GAI) Models

- Variational Autoencoders (VAEs)

- Generative Adversarial Networks (GANs)

- Autoregressive Models

- Diffusion Models

- Information-Theoretic Perspective of GAI Models

- Examples and Applications

Expected impact (Learning Objectives):
After attending this tutorial attendees will understand:

- How probability, latent variables and Bayesian theory enables machines to generate new data

- Why Information Theoretic concepts such as KL divergence, mutual information and entropy play an important role in model design

- How deep learning architectures are based on variational inference and optimization theory

- How GANs pose learning as a game between two neural networks

- How large language models and diffusion models are trained to generate coherent sequence and images.

- How to evaluate generative models using Fréchet inception distance (FID), Inception Score etc.

Targeted Audience.
- Students (graduate level), Engineers and Researchers interested in designing GAI models for different and interested in exploring new ideas for research.
- The material presented here will help new comers to the field and also help practicing engineers (involved in both the theory, algorithm and implementation issues) and researchers these important areas.

List of Speakers and Affiliations:

Instructor(s): Dr. Manas Deb and Prof. Tokunbo Ogunfunmi
Email Address: mdeb@scu.edu, togunfunmi@scu.edu
Manas Deb received his bachelor's degree in computer engineering from India and his M.S. and Ph.D. degrees in electrical and computer engineering from Santa Clara University. He is currently a research associate at SCU. His research work at SCU involves using information theory to understand the underlying learning process of deep neural networks. He has been working with Broadcom Inc for more than 20 years where he has been involved with developing wireless algorithms for Broadcom's WiFi chips. Manas is interested in machine learning, statistical signal processing, information theory and wireless digital communication theory.
Tokunbo Ogunfunmi received the B.S. (first class honors) degree from Obafemi Awolowo University, Nigeria, and the M.S. and Ph.D. degrees from Stanford University, Stanford, California, all in Electrical Engineering. He is currently a Professor of Electrical and Computer Engineering, a David Packard Endowed Faculty Fellow and Director of the Information Processing and Machine Learning Research Laboratory at Santa Clara University (SCU), Santa Clara, California. From 2010-2014, he served as the Associate Dean for Research and Faculty Development for the SCU School of Engineering. His current research interests include machine learning, deep learning, speech and multimedia (audio, video) compression, digital and adaptive signal processing and applications and nonlinear signal processing. He has published over 250 refereed journal and conference papers in these areas. His recent papers published in *Entropy* journal titled "An Overview of Variational Autoencoders for Source Separation, Finance, and

Bio-Signal Applications" and "Information-Theoretical Analysis of a Transformer-Based Generative AI Model" will be used as two of the resources for some of the tutorial materials.
Website
Recent Publications
Dr. Ogunfunmi currently serves on the Editorial Board of the *IEEE Transactions on Signal Processing* and the *Circuits, Systems and Signal Processing (CSSP)* journal. Previously he served on the editorial boards of *IEEE Transactions on Circuits and Systems-I, IEEE Transactions on Circuits and Systems-II and IEEE Signal Processing Letters*. Recently, he also served as Lead Guest Editor for the *CSSP* journal Special Issue on "Algorithms and Architectures for Machine Learning based Speech Processing" published in August 2019, *Entropy* journal Special Issue on "Adaptive signal processing and Machine Learning Using Entropy and Information Theory", Sept. 2022 and for the *Journal of Signal Processing Systems (JSPS)* Special Issue on 2018 IEEE Workshop on Signal Processing Systems (SiPS).

He has been involved with several IEEE conference committees as a member/chair of the organizing and technical committees. He organized several Special Sessions for IEEE ISCAS previously. He served as the General Chair of the 2018 IEEE Workshop on Signal Processing Systems (SiPS 2018) and as the Technical Program Co-Chair of the 2019 IEEE International Symposium on Circuits and Systems (ISCAS 2019). Dr. Ogunfunmi served the IEEE as a Distinguished Lecturer from 2013-2014 for the Circuits and Systems Society.

Related Publications (with Dr. Manas Deb):
  • Deb M., Ogunfunmi T., "Using information theoretic learning techniques to train neural networks", 51st Asilomar Conference on Signals, Systems and Computers, 2017
  • Ogunfunmi T., Deb M., "On the PDF Estimation for Information Theoretic Learning for Neural Networks", 2018 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference (APSIPA ASC)
  • Ogunfunmi T., Deb M., "Markov Chain Monte Carlo in a Dynamical System of Information Theoretic Particles", The Monte Carlo Methods - Recent Advances, New Perspectives and Applications. IntechOpen, Mar. 09, 2022.
  • Deb M., Ogunfunmi T., "Information Channels of Deep Neural Networks", IEEE 33rd International Workshop on Machine Learning for Signal Processing (MLSP), 2023
  • Deb, M.; Ogunfunmi, T. Information Theoretical Analysis of a Transformer-Based Generative AI Model. *Entropy* 2025, *27*, 589.

Note:
Other recent tutorials given (and conference special sessions organized) by the speaker e.g.
  o Tokunbo Ogunfunmi, **Lead Guest Editor**, Special issue of the journal *Entropy*, titled "Entropy and Information Theory in Machine Learning: Theoretical Insights and Applications", Dec. 2024.
  o Tokunbo Ogunfunmi, **Tutorial**: Connections and Relationships of Adaptive Filtering, Machine Learning and Deep Learning with Applications, *2023 IEEE LASCAS Conference*, Quito, Ecuador, Feb. 2023.
  o Tokunbo Ogunfunmi, **Lead Guest Editor**, Special issue of the journal *Entropy*, titled "Adaptive signal processing and Machine Learning Using Entropy and Information Theory", Sept. 2022. o Tokunbo Ogunfunmi (with Warren Gross) co-organized a **Special Lecture Session** titled "Hardware Architectures and Design Methodologies for Edge Intelligence" at the *2022 IEEE (ISCAS)*, Austin, Texas, May 2022.
  o Tokunbo Ogunfunmi, **Invited Lecturer**: IEEE CAS Society Workshop, African American Webinar Series on Fundamentals on Circuits, Systems and Emerging Technologies, "Introduction to Machine Learning", Full-day tutorial, October 8, 2020 o Tokunbo Ogunfunmi, **Tutorial**: "Principles of Adaptive Filters: Applications, Recent

Advances and Open Problems", *IEEE International Symposium on Circuits and Systems (ISCAS)*, Melbourne Australia, June 2014

o Tokunbo Ogunfunmi, **Tutorial**: Advances in Wireless Local Area Networks for Gigabit Rate Applications , *Proceedings of the 2013 IEEE International Symposium on Circuits and Systems (ISCAS)*, Beijing, China, May 2013.

o Tokunbo Ogunfunmi (with M.J (Sim) Narasimha and Roberto Tognieri), **Tutorial**: Advances in Speech Coding, Speech Recognition and Applications, *Proceedings of the 2012 IEEE International Symposium on Circuits and Systems (ISCAS)*, Seoul, Korea, May 2012.

o Tokunbo Ogunfunmi (with Mrityun Chakraborthy) co-organized a **Special Lecture Session** titled "Recent Advances in Sparse & Non-Linear Adaptive Signal Processing" at the *2012 Asian Pacific Signal Processing Conference (APSIPA ASC)*, Hollywood, California, Dec. 2012.

o Tokunbo Ogunfunmi organized a **Special Lecture Session** titled "Recent Advances in Linear & Non-Linear Adaptive Filters" at the *2011 IEEE International Symposium on Circuits and Systems*, Rio de Janeiro, Brazil from 15-18 May 2011. o Etc.