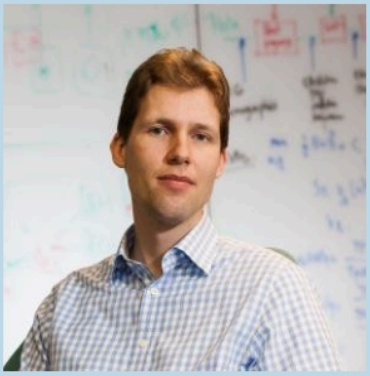
COLUMBIA ENGINEERING

The Fu Foundation School of Engineering and Applied Science

Artificial Intelligence Program Faculty

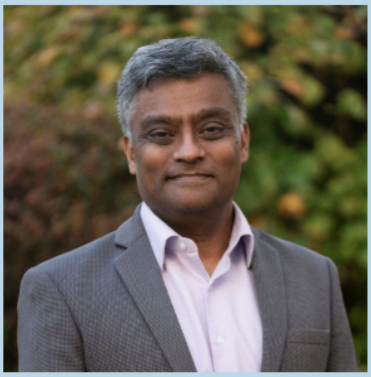
Tony Dear

Senior Lecturer in Computer Science



Ton Dieker

Professor of Industrial Engineering and Operations Research; Chair, Department of Industrial Engineering and Operations Research

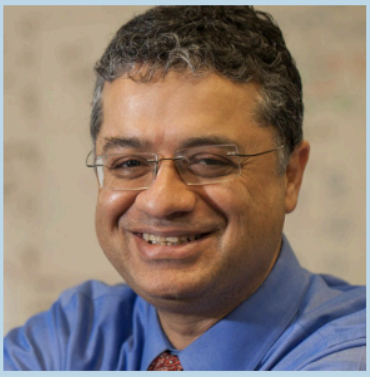


Garud N. Iyengar

Professor of Industrial Engineering and Operations Research; Avanessians Director of the Data Science Institute

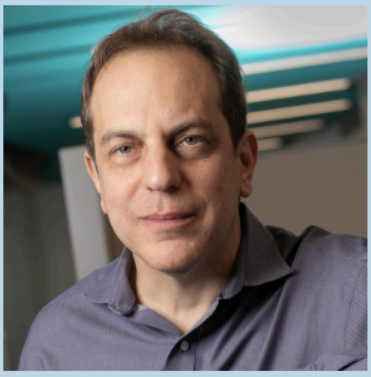
Hardeep Johar

Teaching Professor of Industrial Engineering and Operations Research



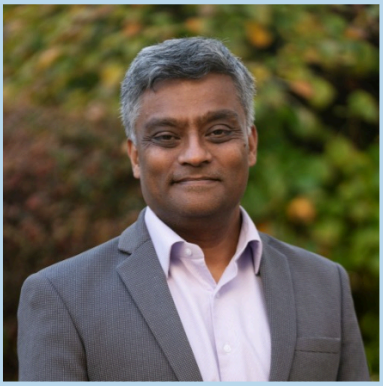
Vishal Misra

RKS Family Professor of Computer Science; Vice Dean of Computing and Artificial Intelligence



Gil Zussman

Kenneth Brayer Professor of Electrical Engineering



Garud N. Iyengar

Professor of Industrial Engineering and Operations Research; Avanessians Director of the Data Science Institute

Garud Iyengar works problems at the intersection of information, control and optimization in diverse settings.

His research group is currently working on problems arising in cellular signaling, labor platforms, power networks, supply chains, multi-armed bandits, and causal inference.

His group work publishes in leading machine learning conferences, including NeurIPS, ICML, AISTATS, EC, and STOC, and a very wide set of journals including Operations Research, Mathematical Programming, MSOM, E-Life and several IEEE journals. His work has been supported by grants from NSF, DOE, and ONR, and grants from several Centers at Columbia.

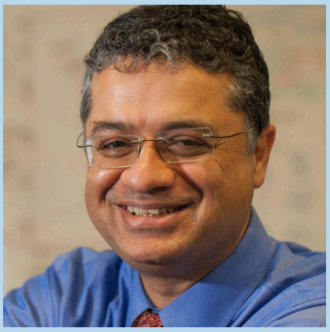
Professor Iyengar earned his B. Tech in Electrical Engineering from IIT Kanpur, and his MS and PhD in Electrical Engineering from Stanford University.

Research Areas

- Data Analytics
- Decision Analysis
- Economics & Computation
- Financial Engineering
- Game Theory
- Manufacturing Systems
- Optimization
- Resource Allocation
- Risk Management
- Supply Chain Management
- Blockchain (Web3.0)
- Business Analytics
- E-commerce
- Energy & Power
- Financial Technology
- Large-scale Optimization
- Matching Platforms
- Urban Logistics

Contact Information

Garud N. Iyengar
1401 Northwest Corner Building
garud@ieor.columbia.edu



Vishal Misra

RKS Family Professor of Computer Science; Vice Dean of Computing and Artificial Intelligence

Vishal Misra's research is in the broad area of modeling and analysis of complex systems.

His work includes both developing mechanisms that make networks work better and faster, and also investigating the economic models that underpin the Internet and their impact on public policy like Network Neutrality. His approach to research is to incorporate fundamental theories like control theory, queueing theory, information theory, and game theory in the design and analysis of networks.

Vishal has worked extensively in the design and analysis of congestion control mechanisms, both for the Internet as well as for data centers. His work, based on applying classical control theory to a differential equation-based model that he developed for Internet traffic, has found its way into becoming part of the DOCSIS 3.1 standard for cable modems and is being deployed worldwide. He has also played a very active role in the public policy debates related to Network Neutrality and the strong recent regulations passed by the Indian and Canadian regulatory authorities are in line with a definition of Network Neutrality he has proposed.

He received a BTech from IIT Bombay in 1992, and an MS and PhD from the University of Massachusetts at Amherst in 1996 and 2000 respectively. Fellow of IEEE and ACM. He has been awarded a Distinguished Alumnus Award by IIT Bombay (2019) and a Distinguished Young Alumnus Award by UMass-Amherst College of Engineering (2014).

Research Areas

- Networks and Distributed Systems
- Artificial Intelligence (AI) and Machine Learning (ML)
- Causal Inference
- Economics & Computation
- Generative AI & Large Language Models
- Wireless, Embedded & Sensor Systems
- Cybersecurity
- Communications
- Control Systems
- Information Theory
- Modeling and Performance Evaluation
- Additional Information

Contact Information

Vishal Misra
512 Computer Science Building
vishal.misra@columbia.edu

COLUMBIA ENGINEERING
The Fu Foundation School of Engineering and Applied Science

ARTIFICIAL INTELLIGENCE

The full-time, on-campus program provides a unified, rigorous AI curriculum anchored in Computer Science and Engineering, plus formalized pathways to apply AI in various fields. The curriculum of the concentrations is jointly planned by faculty at Columbia Engineering and partner schools from across the University.
The master's in artificial intelligence curriculum comprises a foundational set of core Artificial Intelligence courses plus a concentration. The Master's of Science in Artificial Intelligence requires 30 credits of coursework, with at least 18 credits being taken at Columbia Engineering.

The MSAI program features:

- AI core courses (12 points)
- A specialized concentration (12 points)
- An additional 6 points of:
  - General electives, or
  - A two semester Interdisciplinary Capstone project, or
  - Engineering faculty-supervised AI research

Students must also complete the professional development and leadership course, ENGI E4000, as a graduation requirement. Students completing the program will be awarded a Master of Science in Artificial Intelligence degree and receive an annotation of the specific concentration on their transcript/diploma.

FIRST SEMESTER

1. Artificial Intelligence course; choose 1, 3 credits:

1. COMS W4701 | Artificial Intelligence
2. IEOR E4010 | Artificial Intelligence for Operations Research and Financial Engineering (option for Finance/Operations Concentration)

2. Machine Learning course; choose 1, 3 credits:

1. COMS W4771 | Machine Learning
2. IEOR E4525 | Machine Learning for OR & FE
3. ELEN E4720 | Machine Learning for Signals, Information, and Data

For students with machine learning experience, the following courses may be used to satisfy this requirement:

1. BMEN E4470 | Deep Learning in Biomedical Signal Processing
2. COMS W4776 | Neural Networks and Deep Learning
3. ECBM E4040 | Neural Networks and Deep Learning
4. IEOR E4742 | Deep Learning for Operations Research and Financial Engineering

3. NLP or Computer Vision; choose 1, 3 credits:*

1. COMS W4705 | Natural Language Processing
2. COMS W4731 | Computer Vision I
3. COMS W4732 | Computer Vision II
4. ELEN E4830 | Digital Image Processing and Computer Vision

4. 3 credits of concentration electives or 3 credits toward the general elective requirement.

5. ENGI E4000 Professional Development and Leadership, 0 credits.

This degree requirement must be completed by the end of the second semester.

*This can also be taken during the second semester

SECOND SEMESTER

Ethical AI; choose 1, 3 credits:
1. COMS W4710 | Ethical and Responsible Artificial Intelligence
2. ORCS E4201 | Policy for Privacy Technologies

9-12 credits, including concentration electives, capstone, engineering faculty-supervised AI research, or general electives

THIRD SEMESTER

Students must complete the remaining degree requirements. Core courses are expected to be completed by the first and second terms. During the third term, students complete concentration electives and fulfill the remaining elective requirement through one of the following options: general electives, continuation of the capstone project, or engineering faculty-supervised AI research.

COURSE DESCRIPTIONS

COMS W4701 ARTIFICIAL INTELLIGENCE (3 credits)
This course is an introduction to artificial intelligence. It provides the basic foundation for building intelligent computer systems. It will cover five main topics: search, game playing, knowledge representation, planning and machine learning. For each basic technique, we will look at an application whose implementation is based on that technique. Towards the end of the course, we will get a flavor of some of the advanced areas in the field. Assignments for the course will consist of a combination of written and programming assignments. The programming language for the course is Java. Students may also choose to program in LISP, if they prefer.

COMS W4771 MACHINE LEARNING (3 credits)
Topics from generative and discriminative machine learning including least squares methods, support vector machines, kernel methods, neural networks, Gaussian distributions, linear classification, linear regression, maximum likelihood, exponential family distributions, Bayesian networks, Bayesian inference, mixture models, the EM algorithm, graphical models and hidden Markov models. Algorithms implemented in Matlab.

IEOR E4525 MACHINE LEARNING FOR OR & FE (3 credits)
Introduction to machine learning, practical use of ML algorithms and applications to financial engineering and operations. Supervised learning: regression, classification, resampling methods, regularization, support vector machines (SVMs), and deep learning. Unsupervised learning: dimensionality reduction, matrix decomposition, and clustering algorithms

ELEN E4720 Machine Learning for Signals, Information and Data (3 credits)
Introduction to supervised and unsupervised machine learning
Classification and regression models, clustering, sequential modelsLinear / logistic regression, support vector machines, boosting, K-means clustering, mixture models, hidden Markov models
Applications to extraction of information from signals and datasets.

COMS W4721 MACHINE LEARNING FOR DATA SCIENCE (3-credits)
A graduate-level introduction to machine learning. The course covers basic statistical principles of supervised machine learning, as well as some common algorithmic paradigms. Additional topics, such as representation learning and online learning, may be covered if time permits.

COMS W4705 NATURAL LANGUAGE PROCESSING (3-credits)
Learning from, and learning to generate, natural language is one of the core strategies in modern artificial intelligence. Systems built from the tools learned in this class are increasingly deployed in the world. This

section (Section 2) provides a generative models-focused introduction to this field of natural language processing, with the goal of understanding and implementing the foundational ideas beneath state-of-the-art systems.

COMS W4731 COMPUTER VISION I (3-credits)
This course is an introduction to fundamental and advanced topics in computer vision. Topics include image formation and optics, image sensing, binary images, image processing and filtering, edge extraction and boundary detection, region growing and segmentation, pattern classification methods, brightness and reflectance, shape from shading and photometric stereo, texture, binocular stereo, optical flow and motion, 2D and 3D object representation, object recognition, vision systems and applications.

COMS W4732 Computer Vision II (3-credits)
Advanced course in computer vision. Topics include convolutional networks and back-propagation, object and action recognition, self-supervised and few-shot learning, image synthesis and generative models, object tracking, vision and language, vision and audio, 3D representations, interpretability, and bias, ethics, and media deception.

COMS W4710 Ethical and Responsible Artificial Intelligence (3-credits)
Teaches the principles of ethical artificial intelligence across technical and societal dimensions. Combines technical AI and machine learning implementations and ethical analysis. Students will learn to build, audit, and mitigate ethical risks in AI systems using tools like fairness libraries, explainability frameworks, and privacy-preserving techniques.

The master's in artificial intelligence curriculum comprises a foundational set of core Artificial Intelligence courses plus a concentration in areas including:

- AI and Advanced Computing
- Robotics and Perception
- AI and Finance and Operations
- AI and Biomedical
- AI Infrastructure
- AI and UI/UX
- AI and Health and Medicine
- AI and Public Health
- AI and Arts, Creativity, and Media
- Statistical Foundations of AI
- AI and Architecture and Urbanism

GENERAL ELECTIVES

Biomedical Engineering:
- BMCS E4480 | Statistical Machine Learning for Genomics
- BMEN E4460 | Deep Learning in Biomedical Imaging
- BMEN E4470 | Deep Learning for Biomedical Signal Processing
- CBMF W4761 | Computational Genomics

Chemical Engineering:
- CHEN E4020 | Protection of Industrial Intellectual Property

Computer Science:

- COMS W4460 | Principle Innovation Entrepreneurship
- COMS W4706 | Spoken Language Processing
- COMS W4731 | Computer Vision I
- COMS W4732 | Computer Vision II
- COMS W4775 | Casual Inference
- COMS W4776 | Neural Networks and Deep Learning
- COMS W4901 | AI and Storytelling
- COMS W4995 | Topics in CS (Advanced Topics in Computer Security)
- COMS W4995 | Topics in CS (Data-Driven Design for Social Innovation)
- COMS W6113 | Agentic Systems Made Real
- COMS W6706 | Advanced Spoken Language Processing
- COMS W6975 | Advanced Natural Language Processing
- COMS W6998 | Topics in CS (Machine Learning and Climate)
- COMS W6998 | Topics in CS (Reinforcement Learning LLMs)
- CSEE W4121 | Computer Systems for Data Science

Environmental Engineering:

- EAEE E4000 | Machine Learning for Environmental Engineering and Science

Electrical Engineering & computer Science:

- ECBM E4040 | Neural Networks & Deep Learning
- EECS E4750 | Heterogeneous Computing for Signal and Data Processing
- EECS E4764 | Artificial Intelligence of Things
- EECS E6694 | GenAI and Modern Deep Learning
- EECS E6699 | Mathematics of Deep Learning
- EECS E6720 | Bayesian Models in ML
- EECS E6870 | Speech Recognition
- EECS E6892 | Topics in Information Processing (Reinforcement Learning in Information Systems)
- EECS E6893 | Topics in Information Processing (Big Data Analytics)
- EECS E6894 | Topics in Information Processing (Hardware/Software Co-Design for Data Center Processing)
- EECS E6895 | Topics in Information Processing (Advanced Big Data and Artificial Intelligence)
- EECS E6981 | Topics in Information Processing (Operating, Distributed, and Runtime System Optimization through AI/ML Techniques)
- EECS E6991 | Advanced Deep Learning
- EECS E6992 | Deep Learning on Edge

Electrical Engineering:

- ELEN E4620 | Numerical Methods for Data Analysis
- ELEN E4730 | Quantum Optimization and Machine Learning
- ELEN E4830 | Digital Image Processing
- ELEN E6772 | Machine Learning for Computer and Communications Networks
- ELEN E6820 | Speech & Audio Processing & Recognition
- ELEN E6876 | Sparse and Low-Dimensional Models for High-Dimensional Data
- ELEN E6885 | Topics in Signal Processing (Reinforcement Learning)
- ELEN E6908 | Embedded AI

Industrial Engineering and Operations Research:

- IEOR E4530 | AI & Games & Markets
- IEOR E4540 | Data Mining
- IEOR E4550 | Entrepreneurial Business Creation
- IEOR E4650 | Business Analytics

- IEOR E4703 | Monte Carlo Simulation Methods
- IEOR E4737 | AI Applications in Finance
- IEOR E4742 | Deep Learning for OR & FE
- IEOR E4998 | Managing Technological Innovation and Entrepreneurship
- IEOR E6529 | Advanced Reinforcement Learning
- IEOR E6617 | Machine Learning and High-Dimensional Data
- IEOR E8100 | Advanced Topics in IEOR (Agentic AI and Data Economy)
- IEOR E8100 | Advanced Topics in IEOR (Diffusion Models AI & RL)
- IEOR E8100 | Advanced Topics in IEOR (GenAI: Model Alignment)
- ORCS E4200 | Data-Driven Decision Modeling
- ORCS E4529 | Reinforcement Learning

Mechanical Engineering:

- MECE E4611 | Robotics Studio
- MECE E4602 | Intro to Robotics
- MECE E6615 | Advanced Robotic Manipulation
- MEEC E6600 | Mathematics of Machine Learning, Signals, and Control