Avisha Kumar

Doctoral Research Scientist in AI/ML
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EDUCATION

PhD, **Johns Hopkins University**, Electrical & Computer Engineering, GPA: 4.0	Aug 2021 - Dec 2025
MEng, **Cornell University**, Electrical & Computer Engineering, GPA: 3.94	Dec 2019 - May 2020
BSc, **Cornell University**, Electrical & Computer Engineering	Aug 2016 - Dec 2019

TECHNICAL SKILLS

Research Areas: AI/Deep learning (Neural networks, Transformers), Predictive Modeling, Medical Imaging, Supervised/unsupervised ML, Computer vision, Object detection, Segmentation, Physics-informed learning, Operator learning for PDEs, Modeling & simulation of physical systems, Observational & synthetic dataset curation

Tools: Python (Pytorch, TensorFlow, numpy, scikit-learn Pandas, HuggingFace, OOP), Tuning models (NNI), Image processing (OpenCV), Computational modeling, Scientific communication (matplotlib), MATLAB, C, CUDA, GitHub

RELEVANT EXPERIENCE

Neurosurgical Innovation Lab, Johns Hopkins University, Baltimore, MD   Aug 2021 - Present
Machine Learning PhD Research Scientist, <u>AI Team Lead</u>

- Developed transformer-based physics- informed deep operator network to predict ultrasound pressure maps in heterogenous spinal cord anatomy, reducing simulation computation time from hours to seconds with only 2% error
- Benchmarked SOTA object detection models (YOLOv8, SSD, U-net, DETR) to localize injury sites and semantic segmentation models (Segformer, DeepLabv3, SAMed, TransUNet, SwinUNet) to delineate spinal cord soft-tissue in noisy ultrasound images leveraging GPUs with CUDA optimization to enhance performance and efficiency
- Curated a large-scale, open-source ultrasound dataset with ground truth annotations, establishing new benchmarks and novel metrics in ultrasound-based spinal cord analysis
- Developed computational models with image processing to simulate the effects of nonlinear focused ultrasound propagation in patient-specific spinal cord anatomy in psuedo-spectral solvers for precise treatment planning

Computational Neuroscience Lab, Yale School of Medicine, New Haven, CT   June 2020 - July 2021
Computational Research Scientist

- Developed an intracranial EEG preprocessing pipeline in MATLAB to analyze neural data and power differences across seizure types, linking power fluctuations across brain regions to behavioral impairment

Space Systems Design Studio, Cornell University, Ithaca, NY   Aug 2018 - May 2020
Applied Research Scientist

- Worked with the CTO of NASA to develop test protocols for verifying component and electrical subsystem integrity, ensuring optimal power delivery and functionality of a nanosatellite supporting light-sail propulsion research
- Created schematics for electrical systems on the spacecraft and designed 8 printed circuit boards using Altium for the electronics used in the satellite, including the radio, camera, solar charger, solar panels

Neuromorphic Computing Lab, Cornell University, Ithaca, NY   Oct 2019 - May 2020
Computational Research Scientist

- Developed a neuromorphic system with chemosensors and microcontrollers (Raspberry Pi, Intel Loihi chip) for tuning and testing a machine learning algorithm for real-time and robust odor classification

Intel Corporation, Folsom, CA   May 2019 - Aug 2019
Software Engineering Intern

- Implemented test code in Python for write zeros, a feature of Non-Volatile Memory Express (NMVe) which clears logical block addresses for drive security, to validate pre-production solid state drives with concurrent I/O, drive tests across power states, and both safe/unsafe power cycling

Lockheed Martin, Rotary Mission Systems, Owego, NY   May 2018 - Aug 2018
Electrical Engineering Intern

- Designed low-noise bowtie antennas by simulating 3D full-wave electromagnetic fields for optimal signal clarity

PUBLICATIONS

1. "Convolutional Deep Operator Networks for Learning Nonlinear Focused Ultrasound Wave Propagation in Heterogeneous Spinal Cord Anatomy" *Accepted for publication at AAAI Conference on Artificial Intelligence Workshop 2025* **[Oral presentation]**
   Kumar A, Zhi X, Yin M, Ahmad Z, and Manbachi A.

2. "Diffeomorphic Latent Neural Operator Learning for Data-Efficient Predictions of Solutions to Partial Differential Equations" *Accepted for publication at AAAI Conference on Artificial Intelligence Workshop 2025*
   Ahmad Z, Chen S, Yin M, **Kumar A**, Charon N, Trayanova N, Maggioni M

3. "A Patient-specific Preplanning Treatment Algorithm for Focused Ultrasound Therapy of Spinal Cord Injury"
   IEEE EMBS Conference on Neural Engineering 2023, **[Recipient of Best Paper Award]**
   Kumar A, Punnoose J, Leadingham K , Kerensky M, Theodore N, Thakor N, and Manbachi A.

4. "Computational Modeling Approaches for Placement of Wearable and Implantable Ultrasound Devices: Visualization of Beam Propagation through Patient-Specific Anatomy" *SPIE Medical Imaging Conference 2023***[Oral presentation]**
   Kumar A, Tsehay Y, Gonzalez E, Kerensky M, Bell M, Theodore N, Thakor N, and Manbachi A.

5. "A Novel Open-source Ultrasound Dataset with Deep Learning Benchmarks for Spinal Cord Injury Localization and Anatomical Segmentation " *Published on ArXiv, Under review at Nature Scientific Reports 2024*
   Kumar A, Kotkar K, ... Thakor N, and Manbachi A.

6. "Visualizing Tactile Feedback: An Overview of Current Technologies with a Focus on Ultrasound Elastography"
   Frontiers in Medical Technology, 2023
   Kumar A, Leadingham K, Kerensky M, Sankar S, Thakor N, and Manbachi A.

7. "Simulated Driving in the Yale Epilepsy Monitoring Unit" *Epilepsia 2021*
   Kumar A, ... , and Blumenfeld H.

8. "Unidirectional brain-computer interface: Encoding visual stimulus to human f-MRI responses"
   IEEE International Conference on Acoustics, Speech and Signal Processing 2024
   Ruixing Liang, Xiangyu Zhang, ..., **Kumar A,** ..., and Manbachi A.

9. "Tension in tethered spinal cord syndrome can be quantified with ultrasound shear waves"
   Nature Communications Medicine, 2024
   Kerensky M, ... **Kumar A**, ... , and Manbachi A.

10. "Design of the Alpha Cube-Satellite: Technology Demonstration of ChipSat-Equipped Retroreflective Light Sail"
    AIAA 2021 SciTech Forum
    Umansky-Castro J, Mesquita J, **Kumar A**, ..., and Peck M.

11. "Understanding Impaired Consciousness in Frontal Lobe Seizures Investigated with Intracranial EEG"
    Published on BioArXiv, Under Review at Neurology
    Salardini E, Vaddiparti A, **Kumar A**, … , and Blumenfeld H.

12. "The Evolution of Ultrasound Based Prosthetic Control and the Potential of Hybrid Human-Machine Interfaces"
    Under Review at IEEE Reviews in Biomedical Engineering
    Reategui C, **Kumar A**, Dias S. Jr. A, Thakor N, Soares A.

13. "Theranostic Ultrasound Neural Implant for Spinal Cord Injuries" *In Prep*
    Ruixing Li, ... **Kumar A**, ... Manbachi A

AWARDS AND HONORS

2024	Duncan Award for Advancing Research in Statistics ($1560)
2024	IEEE NSF AI in Medicine Fellowship, 32 out of 900 applicants ($2000)
2023	IEEE Neural Engineering (NER) Conference Best Student Paper Award ($500)
2019	Intel Undergraduate Research Program Scholar ($5000)
Fall 2018 – Spring 2020	Cornell University School of Engineering Dean's List
Fall 2016 – Spring 2018	Cornell University School of Engineering Honor's List
2017	International Genetically Engineered Machines Conference Gold Medalist
Summer 2017	Engineering Learning Initiative Award ($5000)

CONFERENCE ABSTRACTS AND PRESENTATIONS

1. "Individualized Spinal Cord Injury Treatment Using AI-Guided Ultrasound"
   NSF-IEEE EMBS AI in Healthcare, Medicine, and Biology Leadership Academy
   Kumar A, Thakor N, Manbachi A

2. Towards Continuous and Comprehensive Spinal Cord Injury Management: Deep Learning on Ultrasound Images for Injury Localization and Anatomical Segmentation
   International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI)
   Applications of Medical AI Workshop 2024 - Accepted
   Kumar A, Kotkar K, Manbachi A

3. "An Optimized and Patient-specific approach for Ultrasound Neural Implant Placement using Physics-informed Operator Learning "
   Indian Institute of Technology Workshop 2024
   Kumar A, Thakor N, Manbachi A

4. "Simulated Driving in the Yale Epilepsy Monitoring Unit"
   American Epilepsy Society Conference 2020.
   Kumar A, Martin R, and Blumenfeld H.

5. "Distinct Ictal and Postictal Changes in Intracranial EEG Power of Mesial Temporal Lobe Seizures with Impaired Consciousness"
   American Epilepsy Society Conference 2023.
   Yadav T, Litvinov B, Culler G, **Kumar A**, … and Blumenfeld H.

6. "Mechanism of Impaired Consciousness in Frontal Lobe Seizures Investigated with Intracranial EEG"
   American Epilepsy Society Conference 2020.
   Salardini E, Vaddiparti A, **Kumar A**, … and Blumenfeld H.

7. "Mechanisms of Impaired Consciousness in Medial Temporal Lobe Seizures Investigated with Intracranial EEG"
   Society for Neuroscience 2021.
   Litvinov B, **Kumar A**, ..., and Blumenfeld H.

8. "Increased Intracranial EEG Power and Duration in Temporal Lobe Seizures with Impaired Consciousness"
   American Epilepsy Society 2021.
   Litvinov B, **Kumar A**, ..., and Blumenfeld H.

9. "A Novel Experimental Paradigm to Investigate Awareness of Action"
   Society for Neuroscience 2021.
   Jin D, Khurana M, Aerts S, Siff E, Kronemer S, Christison-Lagay K, Li J, **Kumar A**, … , and Blumenfeld H.

RELEVANT PROJECTS

Random Convolutional Features on Satellite Imagery for Wildfire Presence Prediction
- Developed a patch-based learning model using random convolutional filters drawn from training data and benchmarked model performance against a standard CNN model for wildfire presence prediction

Deep Learning for Manipulation of Cartoons using Sketches
- Developed a deep learning model for modifying cartoon images with sketch-based alterations provided by the user, achieving 95% accuracy
- Designed an automatic data synthesis pipeline for deep network training and an edge detection algorithm to determine the input mask provided by the user as a modification sketch

Bioimpedance Measurements to Determine Skin Hydration
- Designed a well-isolated, frequency stable, constant current source for bioimpedance measurements based on a mirrored Howland current source and computed the impedance measurements with the data collected from skin electrodes **(won "most innovative design" award in class competition)**

Bio-inspired Coordination for Multi-Agent Systems: Utilizing Cooperative Perception in Autonomous Vehicles
- Developed a highway traffic simulator in Python for modeling safety and traffic speed using vehicle-to-vehicle communication (V2V) in autonomous vehicles (AV)

TEACHING EXPERIENCES AND MENTORSHIP

Artificial Intelligence Subteam Lead, Neurosurgical Innovation Lab, JHU   June 2023 - Current

Course Instructor
Biomedical Engineering Innovation, JHU   June 2024 - Dec 2024
Computational Modeling and Artificial Intelligence for Optimizing Neurosurgery, JHU   June 2024 - Dec 2025

Teaching Assistant
Principles of Design of Biomedical Innovation, JHU   Aug 2020 - Dec 2022
Computer Networks and Telecommunications, Cornell University   Dec 2019 - May 2020
Intelligence Physical Systems, Cornell University   Aug 2019 - Dec 2019

Mentorship
Computer Science Master's Research Supervision (Alina Zhe)   July 2024 - Current
Computer Science Master's Research Supervision (Kunal Kotkar)   Jan 2023 - May 2024

Peer Reviewer
Medical and Biological Engineering and Computing Journal   2021 - 2024

RELEVANT COURSEWORK

Ph.D.   Optimal Transport and Manifold Learning, Theoretical Machine Learning I (**Python**), Theoretical Machine Learning II (**Python**), Data Science, Ultrasound and Photoacoustic Beamforming (**MATLAB**), Compressed Sensing and Sparse Recovery (**MATLAB**), Machine Learning for Signal Processing (**MATLAB**), Principles of Design of Biomedical Instrumentation

M.Eng.   Bio-Inspired Coordination for Multi-Agent Systems (**Python**); Embedded OS (**Python**); Computer Systems Programming (**C**), 5G Cellular Communications

B.Sc.   Embedded Systems (**C**); Intelligent Physical Systems (**C**); Design with Microcontrollers (**C**); Computer Networks & Telecommunications, Computer Architecture (**Verilog**), Operating Systems (**C**)