

Avisha Kumar

Department of Electrical and Computer Engineering
Johns Hopkins University

academic website: avishakumar.com

Cell: +1 (610) 233 – 5876

Email: akumar80@jh.edu

EDUCATION

Aug 2021-
Current **Johns Hopkins University**, Whiting School of Engineering, Baltimore, MD
PhD, Electrical and Computer Engineering
GPA: 4.0

Dec 2019 –
May 2020 **Cornell University**, College of Engineering, Ithaca, NY
M.Eng., Electrical and Computer Engineering
GPA: 3.94

Aug 2016 –
Dec 2019 **Cornell University**, College of Engineering, Ithaca, NY
B.S., Electrical and Computer Engineering

RELEVANT EXPERIENCE

Aug 2021 –
Current **Neurosurgical Innovation Lab**, JHU Dept. of Electrical and Computer Engineering, Baltimore, MD
PhD Research Scientist, AI Subteam Lead
Advisors: [Dr. Nitish Thakor](#) and [Dr. Amir Manbachi](#)
Doctoral Thesis: Individualized Spinal Cord Injury Treatment Using AI-Guided Focused Ultrasound:
Optimization of Neural Implant Placement with Physics-informed Operator Learning

June 2020 –
July 2021 **Blumenfeld Lab**, Yale Dept. of Neurology, New Haven, CT
Postgraduate Computational Neuroscience Research Scientist
Advisor: [Dr. Hal Blumenfeld](#)

Oct 2019 –
May 2020 **Neuromorphic Computing Lab**, Cornell Dept. of Electrical and Computer Engineering, Ithaca, NY
Graduate Research Scientist
Advisors: [Dr. Thomas Cleland](#) and [Dr. Bruce Land](#)
Master's Thesis: Neuromorphic Circuits for Rapid Learning & Robust Classification of Olfactory Signals

May 2019 –
Aug 2019 **Intel Corporation**, Folsom, CA
Software Engineering Intern

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

Aug 2018 –
May 2020 **Space Systems Design Studio**, Cornell Dept. of Mechanical and Aerospace Engineering, Ithaca, NY
Research Scientist
Advisor: [Dr. Mason Peck](#) (former CTO of NASA)

June 2017 –
Dec 2017 **Computer Systems Lab**, Cornell Dept. of Electrical and Computer Engineering, Ithaca, NY
Research Associate
Advisor: [Dr. Jose Martinez](#)

PUBLICATIONS

1. "A Fully Automated Algorithm Towards Optimal Placement for Focused Ultrasound Sources in Therapeutic Applications for Injured Patient-specific Spinal Cord Anatomy"
*IEEE EMBS Conference on Neural Engineering 2023, *Recipient of Best Student Paper Award*
Kumar A, Punnoose J, Leadingham K, Kerensky M, Theodore N, Thakor N, and Manbachi A.
2. "Computational Modeling Approaches for Placement of Wearable and Implantable Ultrasound Devices: Visualization of Beam Propagation through Patient-Specific Anatomy"
SPIE Medical Imaging Conference 2023
Kumar A, Tsehay Y, Gonzalez E, Kerensky M, Bell M, Theodore N, Thakor N, and Manbachi A.
3. "Deep Learning for Spinal Cord Injury Localization and Anatomical Segmentation with a Novel Open-source Ultrasound Dataset " *Under review at Nature Scientific Reports 2024*
Kumar A, Kotkar K, Li R, Manbachi A, and Thakor N.

4. "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.
5. "Simulated Driving in the Yale Epilepsy Monitoring Unit"
Epilepsia 2021
Kumar A, ... , and Blumenfeld H.
6. "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.
7. "Tension in tethered spinal cord syndrome can be quantified with ultrasound shear waves"
Nature Communications Medicine, 2024
Kerensky M, Paul A, Routkevitch D, Hersh A, Leadingham K, Davidar D, Judy B, Punnoose J, Williams A, **Kumar A**, ... , and Manbachi A.
8. "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.
9. "Understanding Impaired Consciousness in Frontal Lobe Seizures Investigated with Intracranial EEG"
Under Review at Brain 2024
Salardini E, **Kumar A**, ... , and Blumenfeld H.
10. "The Evolution of Ultrasound Based Prosthetic Control and the Potential of Hybrid Human-Machine Interfaces"
Under Review at IEEE Reviews in Biomedical Engineering 2024
Reategui C, **Kumar A**, Dias S. Jr. A, Thakor N, Soares A.
11. "Multi-Object Detection of Surgical Tools in Neurosurgery: Introducing an Open-Source Ultrasound Dataset and Deep Learning Assessment" *In Prep*
Steger L, **Kumar A**, Abramson H, Sharma M, Joshi J, Kotkar K, Leadingham K, Theodore N, Manbachi A
12. "An ultrasound-based multi-functional neural implant for spinal cord injury monitoring and therapy" *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)

PROJECTS

Optimal Placement of Ultrasound Neural Implants with Physics-informed Deep Operator Networks

- Developed custom deep operator network (DeepONet) architecture for real-time prediction of ultrasound pressure maps in spinal cord anatomy based on transducer location and patient specific geometry for intraoperative decision-making
- Optimized placement of epidural ultrasound sensor by regularizing results from DeepONet with physics informed learning to ensure that results are bounded by the governing wave equation

Automatic Injury Localization and Spinal Cord Segmentation in Ultrasound Spinal Cord Images: Dataset and Performance Benchmarking

- Benchmarked state-of-the-art deep learning models (YOLO v8, Faster RCNN, SSD, U-net, DETR, RetinaNET) on an experimentally acquired ultrasound spinal cord dataset to localize the site of injury, achieving accuracies as high as 90%

- Benchmarked segmentation models (Segformer, DeepLabv3, U-net, SAMed, TransUNet, SwinUNet) to segment the spinal cord
- Data management, preprocessing, and postprocessing for over 15,000 ultrasound images

Modelling and Simulations of Ultrasound Beam Propagation in Patient-specific Anatomy

- Developed computational models in k-Wave and Wave 3000 Plus to study the effects of focused ultrasound beam propagation in spinal cord anatomy through simulation
- Using image processing and machine learning, automatically denoised and preprocessed a dataset of ultrasound images of injured spinal cord to develop a patient pre-planning algorithm

Mechanisms of Impaired Consciousness in Frontal Lobe and Temporal Lobe Seizures

- Conducted quantitative analysis of data from iEEGs of epileptic patients in MATLAB to determine the effects of seizures on consciousness, relating power across brain regions to behavior impairment
- Consolidated, interpreted, and statically analyzed data from video-EEGs from patients experiencing seizures while driving using a realistic driving simulator in the Epilepsy Monitoring Unit
- Developed intercranial EEG preprocessing pipeline to analyze in MATLAB the differences in power values and ictal onset between clinical, subclinical, unilateral and bilateral temporal lobe seizures

Intel Corporation Internship

- Implemented test code in Python for write zeros, a feature of Non-Volatile Memory Express (NVM), which clears logical block addresses for drive security to verify pre-production solid state drives
- Validated write zeros with concurrent with IO commands, drive tests, and other NVMe features. Tested write zeroes behavior in different power states, active versus inactive namespace ids, with safe and unsafe power cycling. Assess combability with both Windows and Linux operating systems.

Lockheed Martin Rotary Mission Systems Internship

- Conducted an engineering checkout of a radio frequency front end circuit card and debugged the 2 major spurs causing loss of data from the phase locked loop using a network analyzer
- Evaluated the performance of components of a receiver/processor, including base band receivers, digital frequency discriminators using signal generators, and a test bench program
- Designed bowtie antenna models in HFSS and simulated 3D full-wave electromagnetic fields

Design of Nanosatellite for Light-Sail Propulsion Research

- Conducted component and electrical subsystem verification tests using software in Arduino and a Teensy 3.5 microcontroller
- 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

Random Convolutional Features on Satellite Imagery for Wildfire Presence Prediction

- Developed a patch-based learning model using random convolutional filters drawn from training data.
- Compared standard CNN performance with ablated random convolutional kernels.

Deep Learning for Manipulation of cartoons using sketches

- Developed a deep learning model for modifying cartoon images with sketch-based alterations that are provided by the user, achieving 95% accuracy
- Using an automatic data synthesis pipeline for deep network training and an edge detection algorithm to determine a mask that the user inputs as a modification sketch

Neuromorphic Circuits for Rapid Learning and Robust Classification of Olfactory Signals

- Developed a system consisting of an array of chemo sensors for signal detection, an Arduino Mega for temperature control, a Raspberry Pi for signal processing and normalization, and an Intel Loihi neuromorphic chip to implement "learning in the wild" machine learning algorithm
- System samples from the chemo sensors during online inference stage to classify odors, aiming to emulate a mammalian olfactory system

Bio-gaming system for transhumeral amputees

- Developed a system in which transhumeral amputees can control certain keys on the keyboard and a mouse using their leg and mouth, with no reliance on hand, wrists, forearms, or elbows with innovative sensor design (won first place in a class-wide competition)

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 to Increase Safety of Autonomous Vehicles

- Developed a highway traffic simulator in Python to increase safety and traffic speed using vehicle-to-vehicle communication (V2V) in autonomous vehicles (AV)
- Developed the algorithm used in the simulator to randomly generate vehicles with the appropriate sensors, communication, and behavior, and analyzed the number of collisions and average vehicle speed in scenarios with different obstacles
- Demonstrated that the average speed of AVs with V2V in traffic is 1.5 times faster than the human model for every obstacle, and the human model can have up to 28 times more collisions than V2V

Hand-Controlled Bluetooth Vehicle

- Designed a Bluetooth controlled vehicle that can be maneuvered depending on the hand motions of the user. Transmitted information about the position of the user's hand using an accelerometer, PIC32 microcontroller programmed in C, and a Bluetooth module.
- Programmed the vertical and lateral movement of the vehicle with a motor, servo, and h-bridge.

Set and Way Partitioning on a Cavium Server

- Conducted research on the fine-grain cache partitioning in server-class and application of SWAP, which combines Set and Way Partitioning, on a Cavium server

iGEM (International Genetically Engineered Machines) Project Team

- Used CAD software, 3-D printing, and machining to prototype hardware components (camera, LED and Raspberry Pi mount, waterproof case, planter cups) to design a hydroponic system for real-time monitoring and control of oxidative stress in plant water to increase yield by 15 – 20% (**won gold medal in international competition**)

CONFERENCE ABSTRACTS AND PRESENTATIONS

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

TEACHING EXPERIENCES AND MENTORSHIP

June 2023 – Current	AI Subteam Lead <i>HEPIUS Neurosurgical Innovation Lab</i>
June 2024 – Aug 2024	Biomedical Engineering Innovation <i>Course Instructor</i>
Jan 2024 – Dec 2024	Modeling, Simulations, and Artificial Intelligence for Optimizing Neurosurgery <i>Course Creator and Instructor for Johns Hopkins Undergraduates</i>
July 2023 – Current	Computer Science Master's Student Mentorship (Alina Zhe) <i>Master's Thesis Mentor</i>
Jan 2023 – May 2024	Computer Science Master's Student Mentorship (Kunal Kotkar) <i>Master's Thesis Mentor</i>
Aug 2022 – Dec 2022	Principles of Design of Biomedical Instrumentation <i>Graduate Teaching Assistant</i>
Dec 2019 – May 2020	Computer Networks and Telecommunications <i>Graduate Teaching Assistant</i>
Aug 2019 – Dec 2019	Intelligent Physical Systems <i>Undergraduate Teaching Assistant</i>

SKILLS

Languages	Advanced proficiency in English and Hindi
Programming	Python (Pytorch, HuggingFace, Neural Networks, Transformers), Neural Network Intelligence (NNI), MATLAB, CUDA, C, Linux, Bash, Verilog, Latex
Programs	Ultrasound simulation softwares: Wave 3000 Plus, k-Wave, Field-II; Altium (PCB design), Autodesk Fusion 360 (CAD), HFSS (High Frequency Structural Simulator), Persyst (EEG analysis software)
Fabrication	Operation of lathes and mills, circuit development, 3D printing

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)

OTHER ACTIVITIES

2021 – 2024	Medical and Biological Engineering and Computing Journal Peer Reviewer
2022 – 2023	NYC Half Marathon, Baltimore Half Marathon
2018 – 2020	Cornell University Rowing Club
2016 – 2018	Cornell University Jazz Ensemble