

# Avisha Kumar

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Johns Hopkins University

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## EDUCATION

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

Aug 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

## RESEARCH EXPERIENCE

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Aug 2021 –  
Current      **Neurosurgical Innovation Lab**, JHU Dept. of Electrical and Computer Engineering, Baltimore, MD  
*PhD Student, AI Subteam Lead*  
Advisors: Dr. Nitish Thakor and Dr. Amir Manbachi  
Thesis: Individualized Spinal Cord Injury Treatment Using AI-Guided Focused Ultrasound:  
Optimization of Implantable Device Placement with Physics-informed Operator Learning

June 2020 –  
July 2021      **Blumenfeld Lab**, Yale Dept. of Neurology, New Haven, CT  
*Postgraduate Computational Neuroscience Research Assistant*  
Advisor: Dr. Hal Blumenfeld

Oct 2019 –  
May 2020      **Computational Neuroscience Lab**, Cornell Dept. of Electrical and Computer Engineering, Ithaca, NY  
*Master's Student*  
Advisors: Dr. Thomas Cleland and Dr. Bruce Land  
Thesis: Neuromorphic Circuits for Rapid Learning and Robust Classification of Olfactory Signals

Aug 2018 –  
May 2020      **Space Systems Design Studio**, Cornell Dept. of Mechanical and Aerospace Engineering, Ithaca, NY  
*Research Assistant*  
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 Assistant*  
Advisor: Dr. Jose Martinez

June 2015 –  
Aug 2015      **Risbud Lab**, Jefferson Dept. Cell Biology and Regenerative Medicine, Philadelphia, PA  
*Research Intern*  
Advisor: Dr. Makarand Risbud

## WORK EXPERIENCE

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

- Implemented test code in Python for write zeros, a feature of Non-Volatile Memory Express (NVMe), which clears logical block addresses for drive security to verify pre-production SSDs
- 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 compatibility with both Windows and Linux operating systems.

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

- 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

## PUBLICATIONS

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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. "Visualizing Tactile Feedback: An Overview of Current Technologies with a Focus on Ultrasound Elastography"  
*Accepted - Frontiers in Medical Technology, 2023*  
**Kumar A**, Leadingham K, Kerensky M, Sankar S, Thakor N, and Manbachi A.
4. "Tension in tethered spinal cord syndrome can be quantified with ultrasound shear waves"  
*Nature Communications Medicine, Under Review*  
Kerensky M, Paul A, Routkevitch D, Hersh A, Leadingham K, Davidar D, Judy B, Punnoose J, Williams A, **Kumar A**, ... , and Manbachi A.
5. "Understanding Impaired Consciousness in Frontal Lobe Seizures Investigated with Intracranial EEG" *Submitted*  
Salardini E, **Kumar A**, ... , and Blumenfeld H.
6. "Automatic Hematoma Localization and Anatomical Segmentation in Ultrasound Spinal Cord Images: Dataset and Performance Benchmarking" *In Prep*  
**Kumar A**, Kotkar K, Li R, Manbachi A, and Thakor N.
7. "The Evolution of Ultrasound Based Prosthetic Control and the Potential of Hybrid Human-Machine Interfaces" *Submitted*  
Reategui C, **Kumar A**, Dias S. Jr. A, Thakor N, Soares A.
8. "Simulated Driving in the Yale Epilepsy Monitoring Unit"  
*Epilepsia 2021*  
**Kumar A**, ... , and Blumenfeld H.
9. "Design of the Alpha CubeSat: Technology Demonstration of a ChipSat-Equipped Retroreflective Light Sail"  
*AIAA 2021 SciTech Forum*  
Umansky-Castro J, Mesquita J, **Kumar A**, ..., and Peck M.
10. "Unidirectional brain-computer interface: Encoding visual stimulus to human f-MRI responses" *Submitted*  
*IEEE International Conference on Acoustics, Speech and Signal Processing 2024*  
Ruixing Liang, Xiangyu Zhang, ..., **Kumar A**, ..., and Manbachi A.
11. "Fast Density Estimation on One-Dimensional Random Projections in Patch-based Learning" *In Prep*  
*International Conference on Machine Learning 2024*  
Ahmad Z, **Kumar A**, Schmitt J.
12. "Can Ultrasound Nerve Modulation Overtake Electrical Stimulation?" *In Prep*  
Lopez A, **Kumar A**, Thakor N.

## AWARDS AND HONORS

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|                         |   |
|-------------------------|---|
| 2023                    | Johns Hopkins Institutional Nominee for Apple Scholars in AI/ML           |
| 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

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1. "Simulated Driving in the Yale Epilepsy Monitoring Unit"  
*American Epilepsy Society Conference 2020.*  
**Kumar A**, Martin R, and Blumenfeld H.
2. "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.
3. "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.
4. "Mechanisms of Impaired Consciousness in Medial Temporal Lobe Seizures Investigated with Intracranial EEG"  
*Society for Neuroscience 2021.*  
Litvinov B, **Kumar A**, ..., and Blumenfeld H.
5. "Increased Intracranial EEG Power and Duration in Temporal Lobe Seizures with Impaired Consciousness"  
*American Epilepsy Society 2021.*  
Litvinov B, **Kumar A**, ..., and Blumenfeld H.
6. "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.

## PROJECTS

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Aug 2021-  
Current

### **HEPIUS Neurosurgical Innovation Lab**

#### **Optimal Placement of Implantable Device with Physics-informed Deep Operator Networks**

- Developing deep operator network (DeepONet) for real-time prediction of ultrasound pressure maps in spinal cord anatomy based on transducer location and patient specific geometry to maximize therapy to site of injury while minimizing heat damage to surrounding regions
- Determining optimal 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**

- Using experimentally acquired B-mode images of porcine spinal cord before and after injury, benchmarked state-of-the-art deep learning models (YOLO v8, Faster RCNN, SSD, RFCN, U-net, DETR, RetinaNET) to localize the site of injury, achieving accuracies as high as 99.5%
- Benchmarked segmentation models (Mask RCNN, DeepLab, U-net, SAM) to segment the spinal cord
- Developing novel deep learning architecture building on SAM to improve segmentation of sagittal spinal cord 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

#### **A Novel Multi-modal Blood Pressure Prediction Algorithm**

- Developing a segmentation and prediction algorithm using a novel blend of blood vessel size from B-mode images, stiffness from elastography images, blood flow from color Doppler images, and clinical covariates of the patient to predict blood pressure

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|-------------------------|--|
| June 2020-<br>July 2021 | <b>Blumenfeld Lab</b><br><b>Mechanisms of Impaired Consciousness in Frontal Lobe Seizures</b> <ul style="list-style-type: none"> <li>• 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</li> <li>• 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</li> </ul> <b>Mechanisms of Impaired Consciousness in Medial Temporal Lobe Seizures</b> <ul style="list-style-type: none"> <li>• 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</li> </ul> |
| Aug 2018-<br>May 2020   | <b>Space Systems Design Studio</b><br><b>Design of Nanosatellite for Light-Sail Propulsion Research</b> <ul style="list-style-type: none"> <li>• Conducted component and electrical subsystem verification tests using software in Arduino and a Teensy 3.5 microcontroller</li> <li>• 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</li> </ul>   |
| June 2017-<br>Dec 2017  | <b>Computer Architecture Lab</b><br><b>Set and Way Partitioning on a Cavium Server</b> <ul style="list-style-type: none"> <li>• 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</li> </ul>  |
| Sept 2021 –<br>Dec 2021 | <b>Machine Learning for Signal Processing</b><br><b>Manipulation of cartoons using sketches</b> <ul style="list-style-type: none"> <li>• Developed a machine learning model for modifying cartoon images with sketch-based alterations that are provided by the user, achieving 95% accuracy</li> <li>• 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</li> </ul>  |
| Oct 2021 –<br>Dec 2021  | <b>Design of Biomedical Instrumentation</b><br><b>Bio-gaming system for transhumeral amputees</b> <ul style="list-style-type: none"> <li>• 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 (<u>won first place in a class-wide competition</u>)</li> </ul> <b>Bioimpedance Measurements to Determine Skin Hydration</b> <ul style="list-style-type: none"> <li>• 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 (<u>won "most innovative design" award in class competition</u>)</li> </ul>   |
| Oct 2019 –<br>May 2020  | <b>M.Eng. Thesis Project</b><br><b>Neuromorphic Circuits for Rapid Learning and Robust Classification of Olfactory Signals</b> <ul style="list-style-type: none"> <li>• 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</li> <li>• System samples from the chemo sensors during online inference stage to classify odors, aiming to emulate a mammalian olfactory system</li> </ul>  |
| Feb 2020 –<br>May 2020  | <b>Bio-inspired Coordination for Multi-Agent Systems</b><br><b>Utilizing Cooperative Perception to Increase Safety of Autonomous Vehicles</b> <ul style="list-style-type: none"> <li>• Developed a highway traffic simulator in Python to increase safety and traffic speed using vehicle-to-vehicle communication (V2V) in autonomous vehicles (AV)</li> <li>• 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</li> <li>• 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</li> </ul>  |

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|------------------------|---|
| Oct 2018 –<br>Dec 2018 | <b>Design with Microcontrollers</b><br><b>Hand-Controlled Bluetooth Vehicle</b> <ul style="list-style-type: none"> <li>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.</li> <li>Programmed the vertical and lateral movement of the vehicle with a motor, servo, and h-bridge.</li> </ul>    |
| Feb 2017 –<br>Nov 2017 | <b>iGEM (International Genetically Engineered Machines) Project Team</b><br><b>Oxyponics</b> <ul style="list-style-type: none"> <li>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 and consistency by 15 – 20% (<u>won gold medal in international competition</u>)</li> </ul> |

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## TEACHING EXPERIENCES AND MENTORSHIP

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| June 2023 –<br>Current | <b>AI Subteam Lead</b><br><i>HEPIUS Neurosurgical Innovation Lab</i>                                  |
| Jan 2023 –<br>Current  | <b>Computer Science Master's Student Mentorship (Kunal Kotkar)</b><br><i>Master's Thesis Mentor</i>   |
| July 2023 –<br>Current | <b>Research Scientist Mentorship (Siddharth Krishnan)</b><br><i>Postgraduate Mentor</i>               |
| Aug 2021 –<br>Current  | <b>Computer Science Volunteer Tutor</b><br><i>Tutor for 13 high school and undergraduate students</i> |
| Aug 2022 –<br>Dec 2022 | <b>Principles of Design of Biomedical Instrumentation</b><br><i>Graduate Teaching Assistant</i>       |
| Dec 2019 –<br>May 2020 | <b>Computer Networks and Telecommunications</b><br><i>Graduate Teaching Assistant</i>                 |
| Aug 2019 –<br>Dec 2019 | <b>Intelligent Physical Systems</b><br><i>Undergraduate Teaching Assistant</i>                        |

## SKILLS

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| <b>Languages</b>   | Advanced proficiency in English and Hindi  |
| <b>Programming</b> | MATLAB, Python (Pytorch), C, Linux, Bash, Verilog, Latex   |
| <b>Programs</b>    | 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) |
| <b>Fabrication</b> | Operation of lathes and mills, circuit development, 3D printing  |

## RELEVANT COURSEWORK

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| <b>Ph.D.</b> | Optimal Transport and Manifold Learning, Theoretical Machine Learning I ( <b>Python</b> ), Theoretical Machine Learning II ( <b>Python</b> ), Data Science, Ultrasound and Photoacoustic Beamforming ( <b>MATLAB</b> ), Compressed Sensing and Sparse Recovery ( <b>MATLAB</b> ), Machine Learning for Signal Processing ( <b>MATLAB</b> ), Principles of Design of Biomedical Instrumentation |
| <b>MEng.</b> | Bio-Inspired Coordination for Multi-Agent Systems ( <b>Python</b> ); Embedded OS ( <b>Python</b> ); Computer Systems Programming ( <b>C</b> ), 5G Cellular Communications  |
| <b>B.Sc.</b> | Embedded Systems ( <b>C</b> ); Intelligent Physical Systems ( <b>C</b> ); Design with Microcontrollers ( <b>C</b> ); Computer Networks & Telecommunications, Computer Architecture ( <b>Verilog</b> ), Operating Systems ( <b>C</b> )  |

## OTHER ACTIVITIES

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| 2022 – 2023 | IEEE NER Post-Conference Event Planning Committee                      |
| 2021 – 2023 | Medical and Biological Engineering and Computing Journal Peer Reviewer |
| 2018 – 2020 | Cornell University Rowing Club   |
| 2016 – 2017 | Cornell University Jazz Ensemble                                       |