Annesya Banerjee

annesya.github.io

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Research Interests

Auditory Perception, Auditory Prostheses, Computational Neuroscience, Machine Learning, Signal Processing, Psychophysics

Education

Harvard University *Fall '21 - Present*

Doctor of Philosophy, Program in Speech and Hearing Bioscience and Technology

- Thesis: Computational modeling of cochlear implant-mediated auditory perception
- Thesis Advisor: Dr. Josh McDermott; Laboratory of Computational Audition

Jadavpur University *Fall '17 - Summer '21*

Bachelor of Engineering, Department of Electronics and Telecommunication Engineering

- Specialization in Signal Processing and Machine Learning
- Thesis Advisor: Dr. P. Venkateswaran; Texas Instruments Innovation Lab

Research Experience (Industrial)

Research Scientist Intern, Audio AI Computer Vision
Reality Labs, Meta *Summer '24 - Present*

- Developing auditory perception motivated metric for evaluating the intelligibility and quality of speech obtained from speech enhancement systems in open-ear listening conditions.
- Collaborated with the **Meta AI Speech** team to develop automatic speech recognition models as an alternative metric for evaluating speech intelligibility and quality.

Research Experience (Academic)

Graduate Researcher, Laboratory of Computational Audition
Department of Brain and Cognitive Sciences, Massachusetts Institute of Technology *Summer '22 - Present*

- Developing a machine learning based model to simulate cochlear implant-mediated hearing perception for real-world auditory tasks such as speech recognition in noise, naturalistic sound localization, pitch perception.
- Using the fully differentiable modeling framework to optimize the parameters of the cochlear implant processor and guide the development of new processing strategies that may improve auditory task performance.

Graduate Rotation Researcher, Nakajima Lab
Eaton Peabody Lab, Massachusetts Eye and Ear, Harvard University *Spring '22*

- Developed a piezo-electric film based drum shaped middle-ear microphone to be implanted on the eardrum to sense acoustic signals for fully-implantable cochlear implants.
- Evaluated the device performance through simulation, bench-test and experiments on human cadaveric temporal bones.

Graduate Rotation Researcher, Puria Otobiomechanics Lab
Eaton Peabody Lab, Massachusetts Eye and Ear, Harvard University *Fall '21*

- Implemented Simulation based Inference to estimate parameters of the finite element models of middle- and inner ear.
- Analyzed and quantified the error between inferred parameter-based simulation results and data from animal experiments to fine-tune the inference model.

Summer Research Intern
Department of Electrical Engineering, Indian Institute of Science (IISc) *Summer '19*

- Designed and developed the prototype of a multichannel MEMS microphone based acoustic array system to be used for adventitious lung sound localization.

- Performed preliminary experiments on the array system to analyze the possibility of inferring and classifying object shape and sizes from the multichannel acoustic signal.

Undergraduate Research Assistant, Texas Instruments Innovation Lab
Department of Electronics and Telecommunication Engineering, Jadavpur University *Winter '19 - Summer '21*

- Developed the entire hardware and software system of a drone with the capabilities of recording sound, performing real-time processing and immediately identifying the azimuth and elevation location of the recorded sound source(s) relative to the drone position while in flight.
- Performed in-lab and field testing of the system for applicability in search and rescue operations with limited visual cues.

Fellowships and Awards

MIT K.Lisa Yang Brain Body Center Graduate Fellowship **(Awarded annually to only two students across the entire university.)** *Fall '23, '24*
Harvard University Division of Medical Sciences Graduate Student Fellowship *Fall '21*
Jadavpur University Best Student Gold Medal *Summer '21*
IEEE Best Outgoing Student Award, SAARC countries (2nd Position) *Spring '21*
Jadavpur University Gold Medal (across all engineering disciplines) *Summer '21*
Supriya Kumar Basu Memorial Fellowship (Awarded to top rank holder university-wide) *Summer '19*
Jagadish Bose National Science Talent Search Fellowship **(Awarded to only 30 students nationally)** *Fall '17*

Grants and Funding

Department of Telecommunications, Govt. of India - Amount INR 6,00,000 *2020-22*
University of California, Berkeley - Amount $ 1,000 *2020-21*
WeRobotics, USA - Amount $ 15,000 *2019-20*

Publications

Zhang, J., Graf, L., **Banerjee, A.**, Yeiser, A., McHugh, C., Kymissis, J., Olson, E., Nakajima, H., Lang, J., 2024. **An implantable piezofilm Middle ear microphone: performance in human cadaveric temporal bones.** Journal of the Association for Research in Otolaryngology (JARO), pp. 1-9.

Banerjee, A., Nilhani, A., Dhabal, S., Venkateswaran, P., 2021. **A novel sound source localization method using a global-best guided cuckoo search algorithm for drone-based search and rescue operations**. In Unmanned Aerial Systems: Theoretical Foundation and Applications, pp. 377-417. Academic Press.

Conference Abstracts

Banerjee, A., Saddler, M., McDermott, J., 2024. Neural network models of hearing clarify factors limiting cochlear implant outcomes. 8th Annual Conference on Cognitive Computational Neuroscience (CCN).

Patents

Annesya Banerjee, Achal Nilhani. An intelligent cough and speech sensing visual monitoring device. Intellectual Property Rights of India #399949, Year 2022

Selected Talks and Posters

Banerjee, A., Saddler, M., McDermott, J. (June, 2024). Neural network models of hearing clarify factors limiting cochlear implant outcomes. 5th Virtual Conference on Computational Audiology (VCCA). [**Talk**]
Banerjee, A., Saddler, M., McDermott, J. (February, 2024). Understanding cochlear implants using machine learning. 47th Mid-Winter Meeting - Association for Research in Otolaryngology (ARO), Anaheim, California. [**Poster**]
Banerjee, A., Saddler, M., McDermott, J. (November, 2023). Understanding cochlear implants using machine learning. Conference on Advances and Perspectives in Auditory Neuroscience (APAN), Washington D.C. [**Poster**]

Banerjee, A., Saddler, M., McDermott, J. (October, 2023). Understanding cochlear implants using machine learning. 10th Speech and Audio in the North East (SANE) workshop, New York. [**Poster**]

Banerjee, A., Saddler, M., McDermott, J. (October, 2023). Neural network models clarify the role of plasticity in cochlear implant outcomes. HMS Neurobiology X MIT McGovern Institute Neurobiology Now Symposium, Boston. [**Poster**]

Banerjee, A., Saddler, M., McDermott, J. (July, 2023). Neural network models clarify the role of plasticity in cochlear implant outcomes. 40th Conference on Implantable Auditory Prostheses (CIAP), Tahoe, California. [**Poster**]

Banerjee, A., Saddler, M., McDermott, J. (June, 2023). Neural network models clarify the role of plasticity in cochlear implant outcomes. 4th Virtual Conference on Computational Audiology (VCCA). [**Talk**]

Banerjee, A., Saddler, M., McDermott, J. (February, 2023). Neural Network Models of Hearing Through a Cochlear Implant. 46th Mid-Winter Meeting - Association for Research in Otolaryngology (ARO), Orlando, Florida. [**Poster**]

Zhang, J.*, Yeiser, A.*, **Banerjee, A.***, Cary, B., Graf, L., McHugh, C., Kymissis, J., Olson, E., Nakajima, H., Lang, J. (July, 2022). A Comparison of Implantable Microphones Constructed Around a Piezoelectric Polymer. 14th Mechanics of Hearing (MoH) Meeting, Helsingør, Denmark. *equal contributions. [**Talk**]

Yeiser, A.*, **Banerjee, A.***, Zhang, J., Graf, L.,McHugh, C., Song, Y., Kymissis, J., Olson, E., Nakajima, H., Lang, J. (June, 2022). Implantable Piezoelectric-Polymer Microphones for the Middle Ear. 9th International Symposium on Middle Ear Mechanics in Research and Otology (MEMRO), Boulder, Colorado. *equal contributions. [**Talk**]

Motallebzadeh, H., Deistler, M., Schönleitner, F., **Banerjee, A.**, Macke, J., Puria, S. (June, 2022). Training a Machine-Learning Differential Diagnostic Tool for Conductive Hearing Loss Using Mechanistic Models. 9th International Symposium on Middle Ear Mechanics in Research and Otology (MEMRO), Boulder, Colorado. [**Talk**]

Banerjee, A., Saddler, M., McDermott, J. (October, 2022). Neural Network Models of Hearing Through a Cochlear Implant. Harvard University SHBT End of Summer Talk, Falmouth, MA. [**Talk**]

Banerjee, A.. (October, 2020). 5G enabled drone system with audition capabilities - application in search and rescue operations. Dept. of Telecommunications, India - India Mobile Congress. [**Demo**]

Banerjee, A.. (July, 2020). Ways to continue scientific research amidst global pandemic. Overseas Volunteers for a Better India (OVBI) Foundation. [**Invited Talk**]

Banerjee, A.. (February, 2020). Listener Drone for Search and Rescue Operations. WeRobotics Unusual Solutions Final Pitch Event, Nairobi, Kenya. [**Talk**]

Teaching Experience

Lecturer @ Harvard/MIT *Summer '24*
Introduction of Machine Learning System Design
Speech and Hearing Bioscience and Technology Bootcamp Series

Teaching Assistant @ Harvard/MIT *Fall '22*
9.016: Introduction to Sound, Speech and Hearing
Profs. Satrajit Ghosh, Sunil Puria, Heidi Nakajima

Outreach

Mentoring Co-Chair, *Graduate Women In Science and Engineering* *Spring '23 - Present*
Serving as the co-chair of the mentorship program where female graduate students are paired with academic/industry mentors to receive career development guidance.

Seminar Coordinator, *Science In The News Seminar Series* *Spring '23 - Present*
Coordinated and helped the seminar presenters to curate scientific talks suitable to a broad audience.

Member of Special Events Committee,
Harvard Health Professions Recruitment and Exposure Program (HPREP) *Summer '23*
Organized discussion to guide high school students navigate the path of college applications and undergraduate life .

Career Mentor, Native American High School Summer Program *Summer '23*
Mentored native American high school students navigate college application process and identify courses aligned with their desired career path.

Teaching Assistant, Program of Ragon and IMES in Science and Medicine *Fall '21*
Introduced middle and high school students to the world of neuroscience and gave an in-lab walk-through of brain anatomy.

Science Exposure Volunteer, Cambridge Science Festival *Fall '22*
Demonstrated various auditory and visual illusions to the general public.

Co-founder, JU UAV Innovators Lab *Fall '19 - Spring '22*
Non-profit educational organization to provide scientific (software and hardware) resources to students for open-source project development.

Organizing Member and Student Engagement Speaker, Jadavpur University *Fall '18 - '21*
Organized annual science workshop for 100+ high school students; provided hands on training in robotics, circuit making and programming to freshmen; delivered talks for high school students on the functioning and applications of autonomous robotic systems .

Research Supervision

Chanel Cheng (MIT MSRP 2023, Currently senior undergrad, RIT) *Summer '23 - Present*

Technical Skills

General Programming Languages: Python, C, MATLAB, SLURM, LaTeX
Packages: PyTorch, TensorFlow, Numpy, Pandas, SciPy, Scikit-learn
Behavioral Reserach: Amazon Mechanical Turk, Prolific, PsychToolbox
Design Tools: COMSOL, Circuit Maker, Proteus, Xilinx Vivado Suite, Anaconda
Audio Analysis Tools: Audacity, PRAAT
Hardware Design: Microcontrollers (8051, Arduino), Raspberry Pi, Texas Instruments (TI), Digital Signal Processing (DSP) Kit, Analog Devices Analog-Digital-Converters (ADC)

Misc. Personal Research Projects

Viral Cough Cop Device *Spring '20 - Summer '21*

- An intelligent, low-cost (under **$135**) device for first-level screening and identification of potential COVID-19 suspects in public places. Project selected as one of the **Top 32 Global Finalists** of Microsoft and HCL organized Better Health Hackathon 2020.

Moog-Emotion *Spring '21*

- A personalized musical instrument to recognize human emotion through speech and play mood-lifting music. Assistive device for healing mental stress, depression and other psychological disorders. Project selected for demonstration at *Guthman Musical Instrument Fair* 2021 organized by Georgia Institute of Technology. Received **Best Hardware Project** and **Best Presentation Award** by Syracuse University.

AuDiNoise: A deep learning based hybrid filtering approach for acoustic noise suppression. *Fall '20*

- Developed a deep learning and adaptive filtering based hybrid algorithm for joint estimation and suppression of non-stationary background noises from audio signals during teleconferencing.

Echo Debar: Real-Time Acoustic Echo Cancellation by Joint Implementation of Adaptive Filtering and Deep Learning *Fall '20*

- Developed a novel acoustic echo cancellation algorithm that uses classical signal processing filters combined with deep learning models for real-time echo cancellation in telecommunication devices.

Coventilator: Development of Low-Cost Ventilators for Patients during COVID-19 Pandemic *Spring '20*

- Worked as the Technical Leader in an international team of 6 members to design a low-cost ($300), easily deployable, medical grade ventilator system for COVID-19 patients. Available at only 1/10th the cost of ICU ventilators. Our design was selected as the **Winner Project** and received $ 1,000 funding from University of California Berkeley.