Vinayak Agarwal

Curriculum Vitae

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RESEARCH INTERESTS

Auditory Perception, Physical Inference, Computational Cognitive Science
Artificial Intelligence, Physics Simulations, Acoustics, Psychophysics

EDUCATION

Massachusetts Institute of Technology (MIT) *Sep '18 - Present*

Doctor of Philosophy, Department of Mechanical Engineering

- Proposed Thesis: Physics-based synthesis and perception of rigid body contact sounds
- Thesis Advisor: Prof. Josh McDermott; Laboratory of Computational Audition
- *Activities: Vice President, Tang Hall ; Founder, MIT Shruti*

Indian Institute of Technology Bombay (IITB) *July'13 - June'18*

Master of Technology, Department of Mechanical Engineering

- Specialization in Computer Aided Design and Automation with a focus on Acoustics
- Thesis Advisor: Prof. Sripriya Ramamoorthy; Acoustics and Hearing Lab

Bachelor of Technology (Hons.), Department of Mechanical Engineering

- Completed a minor degree in management at SJM School of Management
- *Activities: Founder, English Learning Program ; Senior Mentor, Student Mentorship Program*

RESEARCH EXPERIENCE

Research Scientist Intern
Reality Labs Research Audio *June '23 - Aug '23*
Meta Inc.

Graduate Researcher, Laboratory of Computational Audition
Department of Brain and Cognitive Sciences *Feb '20 - present*
Massachusetts Institute of Technology

Graduate Researcher, Laboratory of Underwater Remote Sensing
Department of Mechanical Engineering *Sep '18 - Jan '20*
Massachusetts Institute of Technology

Undergraduate Research Assistant, Acoustics and Hearing Lab
Department of Mechanical Engineering *May '16 - July '18*
IIT Bombay, India

Research Intern
School of Contemporary Arts *May '16 - July '16*
Simon Fraser University, Vancouver

Research Intern, Equipe Sons
Laboratoire de mécanique et d'acoustique *May '15 - July '15*
CNRS, Marseille, France

Undergraduate Research Assistant, Refrigeration and Cryogenics Lab
Department of Mechanical Engineering *Aug '14 - April '15*
IIT Bombay, India

INDUSTRIAL RESEARCH

Meta Reality Labs Research *Jun '23 - Aug '23*

Research Scientist Intern, Audio Presence

- Successfully augmented the in-house spatial audio rendering engine by identifying and systematically unblocking scientific roadblocks
- Worked on generative audio synthesis, developed and successfully demoed two new product-ready spatial and generative audio renderers to the RL Research leadership
- Implemented a new spatial audio renderer and benchmarked it by successfully designing and conducting psychophysical studies for validation

PUBLICATIONS	**Agarwal V.**, Traer J., McDermott J., 2023. **Sample-efficient learning of auditory object representations using differentiable impulse response synthesis**. Workshop on Differentiable almost everything, The 40th International Conference on Machine Learning (ICML 2023), Honolulu.
	Agarwal V., Cusimano M., Traer J., McDermott J., 2021. **Object-based synthesis of scraping and rolling sounds based on non-linear physical constraints**. Proceedings of the 24th International Conference on Digital Audio Effects(DAFx2021), Vienna , 136–143.
	Agarwal V., Cusimano M., Hu J., Traer J., McDermott J., 2022. **Perceptual separation of object and room decays in contact sounds through generative inference in humans**. (in prep).
	Agarwal V., McDermott J., 2022. **Robust physical inconsistency detection reveals multi-modal intuitive physics through sound in humans**. (in prep).
	Traer J.*, **Agarwal V.***, McDermott J., 2022. **Intuitive Physics in auditory scene analysis of impact sounds**. (in prep).
	Agarwal V. and Ramamoorthy S., 2017. **Predicting the acoustical characteristics of reticulated periodic foam**. Proceedings of the National Symposium on Acoustics, Aligarh, 28-30 Oct.
SELECTED TALKS AND POSTERS	**Agarwal V.** and McDermott J., 2022. Auditory intuitive physics revealed by sensitivity to physical inconsistencies in object interactions. 21st Annual Auditory Perception, Cognition and Action Meeting (APCAM 2022).(**Long Talk**)
	Agarwal V., McDermott J., 2022. Real-time differentiable synthesis and perception of instantaneous and sustained contact sounds based on non-linear physical constraints. 25th International Conference on Digital Audio Effects (DAFx2022) (**Invited Talk**)
	Agarwal V., Cusimano M., Traer J., McDermott J., 2021. Object-based synthesis of scraping and rolling sounds based on non-linear physical constraints. 24th International Conference on Digital Audio Effects (DAFx2021) (**Long Talk**)
	Agarwal V. and Ramamoorthy S., 2017. Predicting the acoustical characteristics of reticulated periodic foam. National Symposium on Acoustics, Aligarh. (**Long Talk**)
	Agarwal V. 2018. Introduction to Mohan Veena and Hindustani Instrumental Music from the Maihar Tradition. Berklee College of Music. (**Invited Lecture**)
	Agarwal V. and McDermott J., 2022. Inferring object interactions from scraping and rolling sounds. Annual Meeting of the Cognitive Science Society (CogSci 2022). (Poster)
	Agarwal V. and McDermott J., 2023. Auditory intuitive physics revealed by sensitivity to physical inconsistencies. Association for Research in Otolaryngology (ARO 2023). (Poster)
	Agarwal V. and McDermott J., 2022. Differentiable object-based synthesis of contact sounds. Society for Speech and Audio in the North-East (SANE 2022). (Poster)

FELLOWSHIPS AND AWARDS	The K.Lisa Yang ICON Graduate Student Fellowship	*Fall '22*
	Ministry of Human Resource Development Fellowship	*Fall '17*
	MITACS Summer Research Fellowship	*Summer '16*
	Charpak Research Fellowship	*Summer '15*
	Undergraduate Research Award	*Spring '15*
	IISc KVPY Fellowship (**top 0.071 %ile**)	*Spring '11*
	National Talent Search Scholarship (**top 0.013 %ile**)	*Spring '10*

DOCTORAL THESIS RESEARCH	**Physics-based synthesis of instantaneous and sustained contact sounds**

- Proposed novel state-of-the-art sound synthesis models for impact, scraping and rolling sounds that are differentiable and based on real-time acoustics simulations
- Added perceptually-relevant control knobs for physical quantities like mass, stiffness etc.
- Designed and conducted psychophysical experiments that show that the proposed model is more realistic and expressive than all the previous counterparts
- Mentored an undergraduate researcher and worked with her to obtain micrometer-level textures of everyday materials using a laser confocal microscope

Physics perception from contact sounds

- Provided the first account of auditory intuitive physics in humans
- Designing and performing psychophysical experiments for evaluating the nature and extent of physical inference from sound in humans
- Identifying perceptually-relevant statistics of the surface texture of everyday materials that are expressed in scraping and rolling sounds
- Computationally modelling inference within the generative model using physical simulations within the differentiable generative models

Cross-modal perception of physics through audio-visual cue integration

- Implemented real-time physics-based audio synthesis in the simulation engine, ThreeDWorld
- Working closely with researchers and engineers from IBM-Watson AI lab to augment audiovisual physics simulations and help them add audition capabilities to their machine perception algorithms
- Supervising a junior grad student to test the internal consistency of perceived physics from audition and vision in humans

Separating object and environmental decay in contact sounds using generative inference

- Testing if humans can separate out different stages of the generative process using psychophysics and computational model for generative inference
- Implementing a differentiable reverb synthesis model for generative inference through SGD
- Computationally learnt a model to replicate human competence in material inference from reverberant sound using analysis-by-synthesis

MASTER'S THESIS	**Acoustic analysis and design of periodic rigid foams** *Spring '16 - Summer '18*

Thesis advisor: Prof. Sripriya Ramamoorthy, Mechanical Engineering
Co-advisor: Prof. Shankar Krishnan, Mechanical Engineering

Forward Characterization

- Validated a CFD model against existing literature to predict macro flow parameters of proposed foams
- Predicted the absorption coefficient on the basis of microscopic parameters of the designed foams using viscous and electric flow simulations; Followed a bottom up approach

Inverse Characterization

- Simulated an impedance tube numerically to predict experimental behavior of stochastic foams
- Developed and compared algorithms for the inference of microscopic parameters from in-house impedance tube and flow experiments using state-of-the-art computational models
- Designed and performed impedance tube experiments to validate the theoretical predictions

TEACHING EXPERIENCE	**Teaching Assistant @ MIT**		
	2.095: Finite Element Methods for Mechanical Engineers	Prof. Anthony Patera	*Spring '20*

Teaching Assistant @ IITB
Responsible for conducting weekly tutorial sessions, assisting the instructor & grading all test papers

ME 310: Automatic Control Lab	Prof. Shashikanth S.	*Spring '17*
ME 311: Microprocessors and Automatic Control	Prof. Shashikanth S.	*Autumn '17*
BB 101: Introduction to Biology	Prof. A. Kunwar & Prof. P. Tayalia	*Spring'17*
BB 101: Introduction to Biology	Prof. Ranjith P.	*Autumn' 14*
PH 108: Basics of Electricity and Magnetism	Prof. Umasankar	*Summer '14*

OUTREACH	**IDKAT podcast with Jim Jeffries**	*Summer '22*

Joined the famous late night show host for a podcast episode as a subject expert having a fun and light-hearted discussion around acoustics and hearing

Skype a Scientist *Spring '22*

Conducted a guest lecture on how processes around us generate sound and how the human auditory system processes sound to fifth graders

Department DEIJ representative *Fall '20 - present*

Organized monthly in-lab discussions to brainstorm solutions to DEIJ issues in the department and regularly met with other departmental representatives to carve out department level policies to promote diversity and inclusion in the BCS research community

MIT Splash *Fall '21*

Exposed high school and middle school students to the world of auditory and visual illusions and how scientists use them to understand human perception

INDIAN CLASSICAL MUSIC

Instrumental: Mohan Veena *Spring '09- Present*

Guru: Pt. Devendra Mishra, Maihar Gharana

Trained under the school of music propagated by Pt. Ravi Shankar. Learning according to the traditional Gurukul system; International semi-professional performer

- Invited for a lecture demonstration at the Berklee College of Music
- Won the freshmen instrumental competition open for musicians of all genres
- Collaborated with jazz and blues music to work on fusion music projects
- Composed live music for dance and drama; performed in the second largest auditorium of Mumbai
- Regularly performed for an audience of 1000+ in showcase events held in 4 different countries
- Proficient with the use of Indian rhythm theory and Tabla paterns

TECHNICAL SKILLS

Programming Languages: Python, C++, Embedded C, FORTRAN
Packages: PyTorch, TensorFlow, SciPy, Scikit-learn
Simulation: Unity, FLUENT, ANSYS, COMSOL, ADAMS, FANUC
Algorithm Development Environments: MAX/MSP, LabVIEW, MATLAB
CAD Software: SolidWorks, AutoCAD, Catia, SketchUp, Design Modeler
Hardware: CNC, Additive Manufacturing, VICON

MISC. ENGINEERING RESEARCH PROJECTS

Investigation of near-source artifacts in continental shelf imaging using wide-area acoustic remote sensing system *Sep '18 to Jan '20*
Guide: Prof. Nicholas Makris *Laboratory of Undersea remote sensing, MIT*

- Worked on identifying large fish shoals using active sensing data collected through a ship expedition in the Atlantic Ocean near the Norwegian coast
- Characterized the effect of seabed scattering on the near-field sensing through Ocean Acoustic Waveguide Remote Sensing (OAWRS)
- Simulated broadband waveguide propogation through the Nordic Seas to quantify the effect of seabed variation and ocean depth on near-field sensing
- Improved near-field sensing accuracy by characterizing the resolution footprint in the near-field using state-of-the-art matched filtering and beamforming techniques

Gesture-controlled music generation using an augmented drumstick *Summer '15*
Guide: Dr. Mitsuko Aramaki *LMA-CNRS*

- Added an Inertial Measurement Unit to a drumstick to extract position, rotation and orientation data
- Implemented a gesture following algorithm in MAX/MSP to learn and follow gestures in real time
- Conducted motion capture experiments on VICON apparatus with a professional drummer to study drumming movements; Successfully tested a prototype in a live concert

Automatic song transcription for electronic music *Summer '16*
Guide: Prof. Arne Eigenfeldt *Simon Fraser University*

- Trained an SVM based model to identify change points in electronic music
- Identified change points in audio by attribution of specific audio features to form and pattern changes in breakbeat and house music; Extended the tool for transcription of other genres

Optimization of Printed Circuit Heat Exchangers *Spring '15*
Guide: Prof. Milind Atrey *Cryogenic Engineering*

- Modeled and simulated different designs using SolidWorks and ANSYS Workbench
- Utilized FLUENT and CFD Post for handling and processing fluid data for computation
- Proposed an alternate design for a 3D printed Printed Circuit Heat Exchanger optimal for cryogenic applications with s-shaped channels

Graph Signal Processing On Brain Signals *Spring '17*
Guide: Prof. Vikram Gadre *Digital Signal Processing*

- Modeled brain signals in the form of graphs by using a dynamic functional approach
- Used data from existing psychological experiments and filtered it to get meaningful information
- Presented a poster in a workshop on signal processing organized by the Government of India

Hi-Fi Audio Amplifier *Summer '14*
Guide: Prof. Dipankar *Audio Engineering*

- Designed a cost effective amplifier with high quality reproduction of sound
- Used LM386, LMC6482, TL071 IC's and basic circuit components to develop a Type A amplifier
- Successfully reduced noise by using analog filters and added bass, treble controls

Finite Element Analysis of Periodic Metal foams *Autumn '16*
Guide: Prof. P. Seshu *Finite Element Methods*

- Tested a new FEA software developed by ISRO by making it go through challenging applications
- Performed static and vibrational analysis on proposed unit cells of periodic metal foam geometries to find out the various structural and forced modes of vibrations

Design of a Continuously Variable Transmission (CVT) system *Autumn '16*
Guide: Prof. T. Bhandakkar *Machine Design*

- Modeled a CVT system in SolidWorks with variable belt sizes
- Analyzed static and vibrational strength of the system by simulating motion and performing finite element testing