HOT TOPIC 8: Toolboxes for auditory research

Toolboxes for auditory modeling, spatial audio, and multisensory research

Organizer: Piotr Majdak, Acoustics Research Institute (ARI), Austrian Academy of Sciences (ÖAW)

Co-organizer: Nicki Holighaus, ARI, ÖAW

ABSTRACT

Auditory research requires many tools, ranging from frameworks for psychoacoustic experiments to toolboxes for spatial-audio signal processing. Research in ecologically-valid extended reality requires the consideration of multisensory perception, involving toolboxes designed for auditory-focused but multisensory stimulation. This hot topic aims at providing the participants with tools to improve their research across a wide range of auditory research. To this end, we will introduce toolboxes and provide hands-on sessions with experts on these toolboxes.

We will introduce the auditory modeling toolbox (AMT) offering a variety of auditory models, from loudness to sound localization. We will introduce the virtual acoustics package (VA) for testing auditory cognitive abilities in interactive virtual environments, followed by the binaural rendering toolbox (BRT), the real-time simulated open-field environment (rtSOFE) for rendering virtual sound sources with their reflections, and the room acoustics simulator (RAZR) to create fast and perceptually plausible immersion. We will introduce the package AFC, a versatile and flexible tool to run alternative forced choice experiments. We also will introduce the brain virtual interactivity platform (BRAVI) focused on the associations between psychophysiological states and the multisensory characteristics of virtual environments. Finally, we will have the large time-frequency analysis toolbox (LTFAT) providing a collection of verified time-frequency algorithms for multichannel audio processing.

TRAINING FLOW

Form: WORKSHOP

In each workshop, the aim is to show students how to use a toolbox for their own research. Each workshop will consist of a brief theoretical lecture and then a longer session of hands on to solve some tasks.

1. (Majdak/Osses/Barumerli) The AMT: The auditory modeling toolbox (AMT)
2. (Aspöck/Fels) VA: The virtual acoustics package
3. (Reyes) BRT: The binaural rendering toolbox
4. (Masullo-Sorrentino) BRAVI: The brain virtual interactivity platform

5. (Seeber) rtSOFE: The real-time simulated open-field environment (rtSOFE)
6. (Ewert) RAZR: The room acoustics simulator (RAZR)
7. (Ewert) AFC: A tool to design and run alternative forced choice (AFC) experiments
8. (Hollomey/Holighaus) LTFAT: The large time-frequency analysis toolbox (LTFAT)

KEY TRAINERS

Janina Fels (janina.fels@akustik.rwth-aachen.de)

Janina Fels is a full professor and director of the "Chair and Institute for Hearing Technology and Acoustics" at RWTH Aachen University, Germany, since November 2020. From October 2012 to November 2020, she was Professor for Medical Acoustics at RWTH Aachen University, Germany. She studied electrical engineering (diploma 2002) at RWTH Aachen University, Germany, where she received her PhD from the Institute of Technical Acoustics (PhD 2008). In 2009, she was a post-doc at the "Center for Applied Hearing Research (CAHR)" at the Technical University of Denmark (DTU) and Widex, Denmark. From December 2012 to October 2015, she was a visiting scientist at the Institute of Neuroscience and Medicine, Structural and Functional Organization of the Brain (INM-1) at Forschungszentrum Jülich, Germany.
In March 2013, she was awarded the Lothar Cremer Prize by the German Acoustics Society for her innovative and pioneering work in the field of binaural technology and medical acoustics. In January 2014, she was appointed to the Young College of the North Rhine-Westphalian Academy of Sciences and Arts. In March 2020, she was elected as a Review Board Member for Acoustics (Review Board Mechanics and Constructive Mechanical Engineering) in the Review Board Election of the German Research Foundation (DFG). She was General Co-Chair of the DAGA 2016 conference (Annual Conference on Acoustics in Germany) and Vice-Chair of the International Congress on Acoustics, ICA 2019, in Aachen, Germany. Her research interests include expanding interdisciplinary research in the field of perception and processing of sound in complex acoustic environments for various listener groups. She studies perception and communication in complex acoustic scenarios, for example, noise exposure in classrooms or open-plan offices. She develops methods that allow listening experiments in artificially created complex acoustic scenes to be as lifelike as possible, using advanced technical systems.

Lukas Aspöck (lukas.aspoeck@akustik.rwth-aachen.de)

Lukas Aspöck received a diploma degree in computer engineering from RWTH Aachen University in 2012. From 2013 until 2020 he was a research assistant in the fields of virtual acoustics, room acoustics, simulation models and psychoacoustics at the Institute of Technical Acoustics (ITA). In 2016 he became the head of the Virtual Acoustics workgroup at this Institute. In 2020,

he finished his PhD project by submitting the thesis titled 'Validation of room acoustic simulation models'. In his PhD project, he was substantially involved in the Round Robin on Auralization and the related BRAS database, a collection of reference scenes for the evaluation of acoustical simulations. After a short period as a post-doctoral researcher, in 2021 he became the Academic manager at the Institute for Hearing Technology and Acoustics (IHTA) and is now responsible for managing and contributing to various research and teaching activities at the Chair of Technical Acoustics (Prof. Michael Vorländer) as well as at the Chair of Hearing Technology and Acoustics (Prof. Janina Fels) at RWTH Aachen University.
He is a member of the German Acoustics Association (DEGA) and the European Acoustics Association (EAA), as well as part of the steering committee of the Acoustical Knowledge Alliance (ASKnow), which creates free online teaching material for five different courses on acoustics. Furthermore, he develops, maintains and distributes the research software RAVEN, a room acoustics simulation and auralization environment which used by various researchers worldwide.

Arcadio Reyes-Lecuona (areyes@uma.es)

Arcadio Reyes-Lecuona is telecommunication engineer, PhD in telecommunication engineering and psychologist. He is currently the head of DIANA research group, focusing his research in virtual and augmented reality, binaural audio and 3D interaction. He has been the main researcher of the University of Malaga contribution to several national and European projects in the field of virtual reality, like the 3D Tune-In project (3D-games for TUNing and lEarnINg about hearing aids) and SONICOM (Transforming auditory-based social interaction and communication in AR/VR). He was the technical coordinator of the 3D Tune-In Audio Toolkit and is author of several publications about the topic in journals and conferences. He is the secretary of EuroXR (the European association for extended reality), a member of the AIPO (Spanish association for Human-Computer Interaction) steering committee and the leader of the Malaga project at AABBA (Aural Assessment By means of Binaural Algorithms).

Bernhard U. Seeber (seeber@tum.de)

Bernhard U. Seeber received the Dipl.-Ing. degree in electrical engineering and information technology and the Dr.-Ing. degree with distinction from the Technical University of Munich (TUM), Germany, in 1999 and 2003, respectively. Next, he was a post-doc at the Department of Psychology at UC Berkeley, USA. In 2007, he joined the MRC Institute of Hearing Research, Nottingham, UK, to lead the Spatial Hearing lab. Since 2012, he is the head of the Audio Information Processing lab and Professor in the Department of Computer Engineering at TUM. He has worked on virtual acoustics since his

PhD, developed selection techniques for head-related transfer functions, the Perceptually Equalized Panning technique, real-time room acoustic simulation and auralization tools (rtSOFE) and several setups for sound field synthesis. His research foci are on signal processing for hearing aids and cochlear implants, on spatial hearing and on non-destructive acoustic testing.
Prof. Seeber is a member of the German Acoustical Society (DEGA), the Association for Electrical, Electronic & Information Technologies (VDE), the Acoustical Society of America (ASA), the Association for Research in Audiology (ARO) and the Bernstein Network for Computational Neuroscience. He heads the technical committee on hearing acoustics in the Society for Information Technology (ITG/VDE) and was member of the executive board of the DEGA from 2016 to 2022. He received the Lothar-Cremer award of the DEGA, the doctoral thesis award of the ITG and the ITG publication award.

Stephan Ewert (stephan.ewert@uni-oldenburg.de)
Stephan D. Ewert studied physics and received the Ph.D. degree from the Carl von Ossietzky Universität Oldenburg, Germany, in 2002. During his Ph.D. project, he spent a 3-month stay as a Visiting Scientist with the Research Lab of Electronics, Massachusetts Institute of Technology, Cambridge, MA, USA. From 2003 to 2005, he was an Assistant Professor with the Centre of Applied Hearing Research, Technical University of Denmark, Lyngby, Denmark. In 2005, he re-joined Medizinische Physik at the Universität Oldenburg, where he has been the Head of the Psychoacoustic and Auditory Modeling Group since 2008. His field of expertise is psychoacoustics and acoustics with a strong emphasis on perceptual models of hearing and virtual acoustics. He has authored various papers on spectro-temporal processing, binaural hearing, and speech intelligibility. He also focused on perceptual consequences of hearing loss, hearing-aid algorithms, instrumental audio quality prediction, and room acoustics simulation.

Massimiliano Masullo (massimiliano.masullo@unicampania.it)

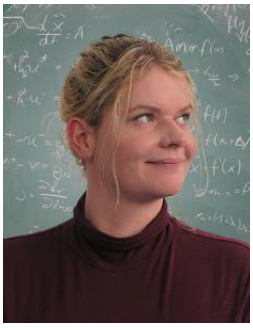
M.Sc. in Mechanical Engineering and Acoustics and Noise Control. Associate Professor of the Department of Architecture and Industrial Design of Università degli Studi della Campania “Luigi Vanvitelli”. Scientific responsible of the multisensory laboratory SENS i-Lab. Member of the research groups Acoustics, Vibration and multisensory Interactions (ACOUVI) and Energy Efficiency & Environment (E3). He is the author of more than 200 scientific publications on acoustics and building physics, which include chapters in books, papers in international journals, proceedings of international conferences. His research activity is focused on investigate the perception, interaction, and responses of individuals to noise in build environment mainly through the: i) Simulation and design of multisensory, hybrid and Immersive Virtual Reality Environment; ii) Development of participatory methods, tools/platform for human centred studies; iii) Experimental sessions on the perceptual, emotional, and physiological responses and their effects.

He serves as a reviewer for many international journals and various research bodies. He is member of the editorial board of scientific journals.

Francesco Sorrentino (francescosorrentino@immensive.it)

PhD in "Environment and Structures Representation, Protection and Safety and Land Management" obtained at the Second University of Naples with a dissertation on *"Multisensorial assessment of pedestrian risk from electric vehicles".* Since 2016 he founded Immensive, a company that actively deals with the virtual reality technology applying it for different fields. In these years he worked with his team on the development of products aiming to enhance the traditional training in the industrial world by introducing VR simulators for the training of high-risk activities. On the other side, he keeps carrying out research activities by supporting companies and Universities with his experience about VR technology.

Clara Hollomey (clara.hollomey@oeaw.ac.at)



Clara Hollomey studied Electrical engineering – Audio engineering at the the University of Music and performing Arts Graz and the University of Technology Graz.
Her PhD research on modeling musical timbre perception was conducted at Glasgow Caledonian University and the MRC Institute for Hearing Research. After a PostDoc at the Technical University of Munich, she developed acoustic SLAM (simultaneous localization and mapping) algorithms at the startup navel robotics. Since 2020, she is part of the workgroup "Mathematics and Signal Processing in Acoustics" at the Acoustics Research Institute of the Austrian Academy of Sciences. She maintains and develops the Large Time Frequency Analysis Toolbox (LTFAT).

Alejandro Osses (ale.a.osses@gmail.com)

Alejandro Osses studied acoustic engineering in Chile and has been appointed in several research positions in Europe since 2012. In 2018 he obtained a Ph.D. from Eindhoven University of Technology, the Netherlands, where he used auditory models in time-domain to simulate (and validate) the perception of similarity using artificial and musical sounds. Since then, he has worked on studying the effects of hearing impairment on psychophysical performance, including the assessment of individual listening strategies in speech-in-noise tasks, which represents the main topic of his current postdoctoral position at ENS Paris, France. Since 2020 he is part of the developing team of the AMT

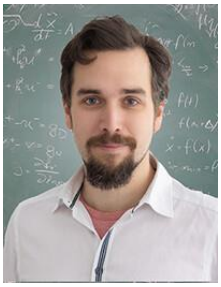
project. He is also the (co-) developer of the fastACI and SQAT toolboxes, which are focused on using “computational listening” to apply reverse correlation and the application of psychoacoustic metrics for the perceptual evaluations, respectively. Alejandro is highly committed to reproducibility and replicability research practices and to open access research.

Roberto Barumerli (Roberto.Barumerli@oeaw.ac.at)
Roberto Barumerli is a young postdoc at the Acoustic Research Institute in Vienna, Austria, studying how human listeners perceive space through sound. With a Ph.D. in information engineering, he focuses on probabilistic inference as a cross-discipline tool to develop and apply models of human behaviour to study listener sound localization abilities. Outside the lab, he prefers building and expanding his modular synthesizer rather than playing it.

Piotr Majdak (piotr.majdak@oeaw.ac.at)

Piotr Majdak studied electrical and audio engineering at the University of Technology and the University of Music and Performing Arts, both in Graz, Austria. In 2008, he received his Ph.D. degree in “Psychoacoustics and signal processing”. He works at the Acoustics Research Institute (ARI) of the Austrian Academy of Sciences at a better understanding of the mechanisms underlying spatial hearing. Piotr published over 50 journal articles and contributed more than 160 times at scientific conferences. Computer algorithms, toolboxes, and reproducible research are his keys to reaching out, see amtoolbox.org and sofaconventions.org.

Nicki Holighaus (nicki.holighaus@oeaw.ac.at)



Nicki Holighaus received a diploma degree in mathematics and theoretical computer sciences from Justus–Liebig–University, Gießen, Germany in 2010. He completed his doctoral studies at the Numerical Harmonic Analysis Group (NuHAG) of the University of Vienna, Austria in 2013, with a thesis on the "Theory and implementation of adaptive time-frequency transforms”.
He joined the Acoustic Research Institute (ARI) of the Austrian Academy of Sciences as a PhD student in 2012, where he currently works as a Senior Research Associate. He is deputy group leader of ARI’s workgroup “Mathematics and Signal Processing in Acoustics” and the coordinator of the “Interdisciplinary Team for Machine Learning in Acoustics” at ARI.
His research focuses on advanced time-frequency methods and applications of frame theory in signal processing, including time-frequency analysis, the mathematical theory and design of adaptive and adapted time-frequency representations, time-frequency processing in acoustics,

phase-aware signal processing and the use of time-frequency representations in machine learning for acoustics.

EQUIPMENT

- Own laptop with Matlab or Octave
- Headphones (own headphones)