



## HOT TOPIC 3: Auralization

### Rendering and spatial reproduction of acoustic scenes

**Organizer:** Tronchin, Lamberto, Dipartimento di Architettura - University of Bologna.

**Co-organizer:** Aspöck, Lukas, Institute for Hearing Technology and Acoustics, RWTH Aachen University.

**Industrial Partner:** Kahle Acoustics

### ABSTRACT

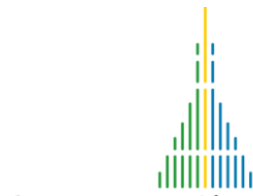
The hot topic "Auralization" will cover aspects of sound field simulation and spatial audio reproduction. Starting with technical aspects and a general introduction to the field of virtual acoustics and the concept of auralization, methods for real-time audio rendering and room auralizations are presented, accompanied by examples in practice. The second part of the course focuses on spatial audio reproduction, approaches such as Ambisonics, Wave-Field Synthesis and other related techniques using loudspeaker arrays. In addition to the lectures and demonstrations, the course will also include hands-on exercises, where participants will be able to create and listen to their own auralizations.

### TRAINING FLOW

The Hot Topic "Auralization" uses three types of course elements to introduce students to the world of sound field rendering and spatial audio reproduction: classical lecture-style teaching, hands-on exercises and demonstrations. It starts with an initial demo session to let the participants experience and understand the challenges and possibilities of spatial audio reproduction using a loudspeaker array. On the second day, the required models of virtual acoustics and sound field simulation are introduced, including an explanation of the most common approaches of Geometrical Acoustics and how these methods are implemented in room simulation software in order to create auralizations. This is followed by a short presentation by the consulting company Kahle Acoustics, who will explain how simulations and auralizations are applied for the planning and renovations of performing arts buildings.

These presentations are then followed by a hands-on session, where the participants learn how to create and modify a simple room acoustic scenario in a 3d editor while experiencing immediate acoustic feedback of the scene modifications. For these sessions, laptops with the required simulation software and headphones are provided to the students, which will be working in pairs on the assignments. The third day starts with a general introduction to Spatial Audio before the concepts of various loudspeaker-based reproduction methods are presented, including Ambisonics, Transaural reproduction, Wave-Field-Synthesis and Vector Base Amplitude Panning. In





forum acusticum 2023



summer school

a tutorial session, students will record and simulate virtual scenes and reproduce them in different ways using a digital audio workstation in combination with freely available VST plugins.

<b>08.09.2023</b>	
15:30-16:00	Introduction to the hot topic 'Auralization'
16:00-18:00	Workshop on technical aspects of real-time rendering and spatial audio reproduction
<b>09.09.2023</b>	
10:30-12:00	Lecture: Introduction to virtual acoustics and room modelling using Geometrical Acoustics (including short demonstrations)
13:30-14:30	Lecture: Binaural Rendering, Room Simulation and Auralization
14:30-15:30	Lecture: Application of acoustic simulation and auralization for performance art buildings
15:30-17:30	Hands-on tutorial: Interactive room simulation and auralization using SketchUp and RAVEN.
<b>10.09.2023</b>	
08:30-09:30	Lecture: Introduction to Spatial
09:30-10:00	Lecture: Two-Channel Stereophony, Multichannel Stereophony, Transaural (1/2)
10:30-11:00	Lecture: Wave Field Synthesis, Ambisonics (2/2)
11:00-12:00	Hands-on tutorial: Recording, Simulation and Editing of Spatial Audio content using a digital audio workstation and VST plugins

## KEY TRAINERS



Peter Svensson has been professor at the department of electronics and telecommunications since 1999, in the acoustics group. His research interests are room acoustics and electroacoustics, in particular computational methods and measurement techniques, but also auralization techniques (virtual acoustics), and psychoacoustics - the perception of speech and music in rooms. Peter Svensson has an MSc in eng. phys. (1988) and a PhD in acoustics (1994) from Chalmers University of Technology in Gothenburg. He has had research visits at Kobe University (1997-98), Rensselaer Polytech Institute (2007), University of Reading (2012-13), and University College London (2017). Previously he has been vice president of the European Acoustics Association (2007-13), president of the Norwegian Acoustical Society (2004-06), and board member of the Swedish Acoustical Society (1996-99).



Jens Ahrens is a Professor within the Division of Applied Acoustics at Chalmers University of Technology. Jens received a Diplom (equivalent to a M.Sc.) in Electrical Engineering/Sound Engineering jointly from Graz University of Technology and the University of Music and Dramatic Arts, Graz, Austria, in 2005. He completed his Doctoral Degree (Dr.-Ing.) at the Technische Universität Berlin, Germany, in 2010. From 2011 to 2013, he was a Postdoctoral Researcher at Microsoft Research in Redmond, Washington, USA, and in the fall and winter terms of 2015/16, he was a Visiting Scholar at the Center for Computer Research in Music and Acoustics (CCRMA) at



Stanford University, California, USA. His primary research interest is signal processing for acoustic transducer arrays.



Franz Zotter is Associate Professor at the Institute of Electronic Music and Acoustics (IEM) and deals with virtual acoustics, Ambisonics, spherical beamforming, and sound reinforcement technologies. He graduated from TU Graz and University of Music and Performing Arts in Graz with a DI (M.Sc.) in electrical and audio engineering in 2004, got his Ph.D. degree from University of Music and Performing Arts in 2009, and his professorship in 2023. Franz Zotter is a member of the German and Austrian Acoustic Societies, the German Tonmeister Society, the Audio Engineering Society, and he co-organizes Europe's Student 3D Audio Production Competition.



Eckhard Kahle was born in Germany in 1963. After obtaining a Vordiplom at the University of Bonn, he continued his studies of physics at Clare College, Cambridge (England), receiving a Master of Philosophy in Physics for his work in modelling the microstructure of wood used by violinmakers. He completed his physics degree in Aachen, Germany, with a major in acoustics and then joined the room acoustics group at IRCAM working on an objective model of the perception of acoustical quality in concert halls, opera houses, and recital halls leading to his doctoral thesis. In 2001, Eckhard Kahle founded his own company, Kahle Acoustics, which specialises in acoustics consulting for performing arts buildings, frequently collaborating with some of the world's most prestigious architects.



Lamberto Tronchin is an associate professor at University of Bologna since 2011, he is active in applied acoustics, energy efficiency. His interests mainly regard room acoustics, where he has worked on developing new methods to measure acoustic quality in rooms and designing theatres and auditoria, musical acoustics where he has developed new vibro-acoustic parameters (IAR) and emulated nonlinear sound behaviour of musical instruments by means of Volterra series, energy efficiency, where he is studying new materials for energy efficiency in buildings. He is involved in EU project (POR FESR) and in National projects (PRIN). He is author of more than 230 papers, he has been Plenary Lecturer at several International Congresses. He is also inventor of an international patent belonging to University of Bologna, namely "Method for artificially reproducing an output signal of a non-linear time invariant system".



Lukas Aspöck is the academic manager at the Institute for Hearing Technology and Acoustics at RWTH Aachen University, organizing and contributing to various research and teaching activities in the area of acoustic simulation and auralization. After receiving a diploma degree in computer engineering, he became a research assistant at the Institute of Technical Acoustics in 2013 and submitted his PhD

thesis on the validation of room acoustic simulation in 2020. He is a member of the German Acoustics Association and the European Acoustics Association, as well as the steering committee of the Acoustical Knowledge Alliance (ASKnow), which creates free online teaching material for five different courses on acoustics. Furthermore, he maintains the software RAVEN, a room acoustics simulation and auralization environment which used by various researchers worldwide.

## ACCADEMIC TUTORS



Marco Berzborn holds a M.Sc. degree in electrical engineering and is a doctoral candidate at RWTH Aachen University, Germany. His dissertation focusses on the spatio-temporal analysis and quantification of sound fields in reverberation rooms. His further research interests include microphone and loudspeaker array based analysis and synthesis methods for directionally dependent reverberation as well as inverse estimation methods for sound absorption.

## EQUIPMENT

- For groups of two students, Laptop and headphones are provided by RWTH Aachen University. These devices have software prepared for the hands-on session of the hot topic.
- Simple loudspeaker setup in course room: If available, a two loudspeaker setup (e.g., two identical near-field monitors on stands) is used to demonstrate the basic principle of spatial audio production (Crosstalk-Cancellation + Panning techniques; Jens Ahrens & Franz Zotter)

## ABOUT COMPANY

Kahle Acoustics, founded in 2001 by Eckhard Kahle and located in Brussels, Belgium, specialises in acoustics consulting for concert halls, opera houses, theatres, and auditoria. Their projects include new buildings, renovations and acoustic improvements, as well as the conversion of existing and “found” spaces. Rather than applying preconceived ideas, Kahle Acoustics seeks optimised solutions that take context, culture, architectural design and artistic merit into account. In every case, the goal is to find a perfectly adapted solution that optimises the acoustics along with all other requirements. To achieve this aim, and to avoid acoustic solutions that are “bolted on”, Kahle Acoustics is proactive in collaborating with the project architect, theatre consultant and user/client to integrate acoustics right from the very start.

Kahle supports the summer school by giving a presentation on how auralization is applied in their projects.