SONICOM

YEAR IN REVIEW
2024

FOREWORD

We thought that SONICOM's third year had been the busiest and most exciting, and that was true then but…the fourth year has been even more fascinating. After the extensive scientific dissemination activities of Summer 2023 (including the Royal Society Summer Science Exhibition) and the Research Sandpit in Glasgow, the focus moved back to core research on immersive audio and spatial acoustics across all five of SONICOM's research themes: Immersion, Interaction, Integration, Experience, and Beyond.

Research teams have produced significant results advancing our general understanding of spatial hearing mechanisms, in addition to developing methods and tools for virtual spatial audio rendering, including the measurement and synthesis of individual HRTFs, the estimation of HRTFs using parametric pinna models and/or photogrammetry, and the rendering of directional sound sources features, to name but a few.

Similarly, we have carried out several studies looking at higher level perceptual processes. Beyond the flagship study on proxemics, which produced very interesting results on the relationship between the distance of a speaker and their perceived personality traits, other experiments have looked at interactions in complex simulated environments and augmented reality scenarios.

A major part of 2024 included the task of integrating SONICOM developments into a usable framework, the Binaural Rendering Toolbox, which will feed into our evaluation work and our efforts to ensure all the tools and models will keep existing and, potentially, being developed after the project. The build of our self-personalising headphones also moved forward, and we now have a functional prototype that has been deployed in experimental settings.

Our work on defining evaluation scenarios ramped up in 2024, significantly involving our SME partners in the design of the evaluations. We are now ready to start working on the implementation, aiming to start carrying out actual experiments and installations in 2025.

In addition to the release of several data, models and tools through various existing channels, the SONICOM ecosystem design has now been completed and we are working on its implementation and, ultimately, its release. In addition to this, we launched and completed the first Listener Acoustic Personalisation (LAP) challenge. This was a big success for SONICOM, as several EU and overseas participants were involved, and both the launch and the closing events were hosted within high-impact conference venues.

As for the first three years, the impact of the work carried out so far has already been evidenced by the contribution of SONICOM in the release and update of tools and datasets widely used within the immersive audio research community!

So…again, full speed ahead!

Lorenzo Picinali,
SONICOM Lead Investigator,
Imperial College London

HIGHLIGHTS OF 2024
RESEARCH THEME: IMMERSION
Improving the immersion of spatial audio rendering in Augmented/Virtual Reality (AR/VR)

Theme lead: Brian FG Katz, Sorbonne University

SONICOM's work within the Immersion theme was extensive, and all relevant deliverables and milestones were completed within the past year.

Looking at the different subtasks, we have explored diverse techniques to enhance the accuracy and effectiveness of HRTF databases and models, collectively advancing our understanding of HRTFs and their implications for enriching spatial audio experiences.

A detailed survey on machine learning techniques for HRTF individualisation was published, together with other studies exploiting data-based techniques for dealing with spatial acoustics personalisation.

On the topic of spatial hearing perception, we have covered a wide range of matters, including HRTF selection, HRTF impact on speech, user-system adaptation in binaural audio, the effects of Head-Mounted Displays (HMDs) on sound localisation, auditory modelling, and Bayesian models for sound source localisation.

Finally, we have carried out exploring the integration of real and virtual acoustic environments in the context of Audio Augmented Reality. Our focus was on techniques to achieve realistic room acoustics in virtual settings, optimising late reverberation algorithms, and simulating room acoustics in dynamic scenarios.

Publications from this research theme

On the accuracy of finite-difference time-domain simulations of head-related transfer functions as a function of model complexity

Learn more

A Survey on Machine Learning Techniques for Head-Related Transfer Function Individualization

Learn more

HRTF Upsampling With a Generative Adversarial Network Using a Gnomonic Equiangular Projection

Learn more

Spatial release from masking in the median plane with non-native speakers using individual and mannequin head related transfer functions

Learn more

HIGHLIGHTS OF 2024
RESEARCH THEME: INTERACTION
Understanding the interactions between the physical, psychological and behavioural

Theme lead: Alessandro Vinciarelli, University of Glasgow

Immersive audio and cognition

During 2024, we reached a conclusion for SONICOM's work in Interaction. Our results show that the key-assumption underlying this work is correct: that immersive audio environments can be considered as interfaces not only for our senses, but also for our psychology and cognition.

In fact, the work revolving around the flagship scenario of the research theme (Automatic Personality Perception in 3D audio immersive environments) show that listeners tend to automatically attribute personality traits to speakers they hear for the first time in an immersive environment, exactly as it happens in face-to-face social interactions.

Furthermore, the results show that the distance of the speaker, as perceived by the listeners, interplays with the attribution of the traits, a phenomenon that it would not be possible to explore without the help of 3D immersive environments.

Sound localisation

The problem of personality perception was only one of the many scientific challenges addressed in our work in 2024. In line with previous years, major efforts were done towards the study of localisation - the ability of correctly identifying the position of a sound source in space.

Furthermore, several studies and publications have addressed adaptation and personalisation of HRTFs, with a particular focus on perception (one of the three elements addressed in this theme, along with action and cognition).

Finally, the researchers involved in our work addressed the possibility to use immersive audio environments as an interface through which people can experience co-presence with others or play audio-based games.

Publication Spotlight

Is Distance a Modality? Multi-Label Learning for Speech-Based Joint Prediction of Attributed Traits and Perceived Distances in 3D Audio Immersive Environments

Publication Spotlight

On the generalization of accommodation to head-related transfer functions

HIGHLIGHTS OF 2024

RESEARCH THEME: INTEGRATION

Integrating SONICOM's various research tools and outputs into an accessible framework

Theme lead: Arcadio Reyes-Lecuona, University of Malaga

In 2024, the SONICOM project marked a key achievement with the official release of the Binaural Rendering Toolbox v2.0 (BRT).

Designed as a virtual laboratory for psychoacoustic experimentation, the BRT integrates algorithms from the 3D Tune-In Toolkit into a new open and extensible architecture, offering a suite of libraries, applications, and tools to create dynamic and reproducible acoustic environments.

Key Components and Features:

- **BRT Library: A modular C++ library for modelling sources, listeners, and acoustic environments.**
- **BeRTA Renderer: A standalone application for audio rendering, controllable via OSC commands.**
- **BeRTA GUI: A graphical interface that simplifies the control of the renderer and allows users to explore custom configurations.**

The BRT provides flexibility for a variety of users: from developers integrating it into their applications to those seeking an intuitive tool for testing and demonstrations. It also extensively supports SOFA files (AES69-2022) for managing HRTFs, BRIRs, binaural filters, directivities, and near-field compensation. The launch of the BRT 2.0 includes comprehensive technical documentation and user-friendly applications that facilitate its adoption within the community. For more details, visit the official BRT repository and online documentation.

Self-personalising headphones

Our work with USound on self-personalising headphones is also moving forward: a functional prototype has been created, and we are now working on the AI software components.

Open-access research tools

SONICOM has a variety of openly accessible tools for the research community, from datasets to MatLab toolkits.

View our open-access tools

HIGHLIGHTS OF 2024

RESEARCH THEME: EXPERIENCE

Evaluating our results in an ecologically valid manner

Theme lead: Areti Andreopoulou, National and Kapodistrian University of Athens

2024 was been a very productive year for our Experience research in SONICOM. We've reached a point where we can now conduct ecologically valid experiences, pertinent to real-life applications, in order to test the research and results of other parts of this project. Our evaluation evolves around two main pillars: audio-first and audio-only applications, where audition is either the primary or the only modality, respectively.

We have identified and are currently exploring several such evaluation scenarios, including but not limited to:

- Immersive Teleconferencing Experiences
- Remote Music Instruction
- Virtual Music Experiences with Authentic Acoustic Conditions
- Navigation of Visually impaired and Blind Individuals
- Immersive Cultural Heritage Applications
- Immersive Installations.

The implementation of these studies will take place over the course of the rest of the project.

Publication Spotlight

Exploring the Directivity of the Lute, Lavta, and Oud Plucked String Instruments

Partner spotlight

Learn more about the SMEs in SONICOM working across the Experience research theme

Creative technology company building immersive experiences

The world's first spatial audio navigation app

HIGHLIGHTS OF 2024

RESEARCH THEME: BEYOND
Ensuring that SONICOM's outputs remain available beyond the project

Theme lead: Piotr Majdak, Austrian Academy of Sciences

The Listener Acoustic Personalisation (LAP) Challenge

In 2024, The LAP challenge was launched to tackle key challenges facing immersive audio technology, advance the state of the art, and contribute to the development of standardised metrics for personalised spatial audio.

The inaugural edition of the challenge concentrated on two fundamental aspects of head-related transfer functions (HRTFs): spatial sampling and interpolation.

The award ceremony took place on August 29 at the European Signal Processing Conference (EUSIPCO) in Lyon, France, and the winners were:

- In the category "HRTF normalisation for merging different HRTF datasets": Jiale Zhao et al. with the contribution "Normalization of HRTFs based on Neural Networks";

- In the category "Spatial HRTF Upsampling": Yoshiki Masuyama et al. with the contribution "Retrieval-Augmented Neural Field for HRTF Upsampling and Personalization".

The challenge was sponsored by the IEEE Signal Processing Society and raised attention of many research groups.

Access all challenge results

The SONICOM Ecosystem

Major progress also took place on the SONICOM Ecosystem, which will be an ecosystem for auditory data closely linked with AI-based and auditory model implementations as well as tools for binaural rendering, reinforcing the idea of reproducible research beyond the SONICOM project.

In 2024, we released the ÖAW Datathek, which will serve as the backbone of the Ecosystem. It provides DOIs for general research data and will serve as an archive for the hearing-related research data of the Ecosystem. This milestone paves the road for the ongoing implementation of the Ecosystem's front-end.

HIGHLIGHTS OF 2024

ENGAGEMENT
The SONICOM team continues to engage with a variety of audiences at public events

Imperial Lates: AI

Imperial Lates: Senses

Keep up to date with SONICOM on social media

OUR PARTNERS

IMPERIAL

SCIENCES SORBONNE UNIVERSITÉ
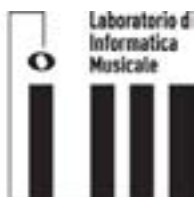
∂AM — Institut Jean le Rond d'Alembert

ÖAW — AUSTRIAN ACADEMY OF SCIENCES

UNIVERSIDAD DE MÁLAGA

UNIVERSITÀ DEGLI STUDI DI MILANO — DIPARTIMENTO DI INFORMATICA

Laboratorio di Informatica Musicale

HELLENIC REPUBLIC — National and Kapodistrian University of Athens

LabMAT

University of Glasgow

Reactify — ADDING NEW DIMENSIONS TO MUSIC

Dreamwaves

U))) SOUND

SONICOM consortium at the 2024 Annual Meeting at Sorbonne University