

# Music and the Internet of Things: Physical Computing, Creativity, and Sensory Heritage

Report on the 3rd workshop in the [Experimental IoT: Explorations in Sound Art and Technology \(EXIoT\)](#) project.

This one-day workshop had a broad scope and a specific aim: to identify a research agenda for IoT and music which addresses both how IoT can benefit from the music domain and how music can further benefit from IoT. Topics discussed included physical computing, materiality at the digital-physical intersection, sensory heritage, and the field of experimental humanities (digital prototyping as a research method) - all in a music context, ranging from performance to the design of new devices and artefacts.

The workshop was held in the [Oxford e-Research Centre](#) on June 1<sup>st</sup> 2023.

## Co-Organisers

- [Alan Chamberlain](#) - University of Nottingham, [PETRAS](#) and [UKRI TAS Hub](#)
- [David De Roure](#) - University of Oxford, [PETRAS](#)
- [Emanuela Vai](#) - University of Oxford, [Digital Humanities and Sensory Heritage Network](#) at [TORCH](#); and PI of EU funded project on '[Fantastic Musical Instruments of the Global Renaissance: DH and Heritage](#)'

## Background

Music as we practice it today adopts digital techniques throughout its course: from the process of composition, performance and recording to production, distribution, listening and sharing. Yet it is also deeply a 'physical' process where materiality and embodiment - for example musical instruments and performance - remain essential. Above all it involves human interaction throughout the process of music creation, and that interaction is now digital as well as physical.

The Internet of Things provides a connection between the digital and physical worlds - the cyberphysical intersection. How then does it feature in music? And what can we learn about IoT from the case study that music provides?

This workshop brought together music practitioners from a variety of fields with a common interest in digital methods. We were pleased to co-host with Oxford's [Digital Humanities and Sensory Heritage Network](#) and the [Creative Impact](#) strand of the UKRI Trustworthy Autonomous Systems (TAS) Hub, welcoming a broad disciplinary range of scholars. This workshop emphasised the perspectives of arts, humanities and cultural heritage, as well as practice research, further strengthening the human aspects of the sociotechnical mission of PETRAS.

This report is provided as an appendix to the EXIoT report as the workshop was held on the day after the award period, for logistical reasons.

## Speakers

The workshop featured a series of expert talks:

- [Steve Benford](#) - The Carolan Guitar
- [Sam Salem](#) - Midlands - a septet for voice, electric guitar, keyboards, string trio, bass clarinet, objects, electronics, tape & dual video projection.
- [Hongshuo Fan](#) - The interactive multimedia performance system and artistic practice in the IoT era
- [Robert Laidlow](#) - Silicon - a large-scale work for orchestra using artificial intelligence

These varied from a focus on an instrument (the Carolan Guitar) to hybrid compositions and performances, enabling us to discuss the digital-material intersection and, importantly, also to discuss the *process* of creating the performances.

We also had a demonstration of a device designed by a 4th year MEng Engineering Science, Julie Yeow. This was a "digital theremin" and served as a provocative case study, taking aspects of the original theremin into the digital domain. Realised through IoT hardware, it was also an example of "making" a digital instrument, with a design that could have many applications.

We welcomed the many contributions to the discussions from our other participants, including [Carolyn Ten Holter](#) from the [Responsible Technology Institute](#), [Karl Kügle](#) from Oxford's Music Faculty, Graham Klyne from the Oxford e-Research Centre, and [Andrew Cusworth](#) from the Digital Scholarship @ Oxford (DiSc) team.

## Discussion topics

A broad range of topics attracted many insightful discussions. These rough categories are a crude post hoc rationalisation of deeply entwined conversations:

- *Cyberphysical*: Finding the glitches, finding the surprises, finding what makes you think; Artcodes to link physical objects to their digital stories; socio-material - how the digital affects social practices.
- *Making*: "electronics" in our practice and performances; democratised access to instrument creation and augmentation; the digital theremin as an open platform; how artists will explore the boundaries and constraints of a design.
- *Music*. Discussion of compositional processes including field recordings, electronics, software tools, AI; the identity of an instrument/artefact includes its history in all its forms; creativity and the cognitive-to-autonomic axis; accessible instruments; orchestra as machine.

- *Humanities*: How the past informs the present and the future; the role of archives and museums; curation of digital art and artefacts; aura; ephemerality; intangible heritage; human propensity to find meaning.
- *AI*: Is AI just a glorified sampler? The growing confusion of AI and ML; countering the stark fashionable focus on AI - we focus on the music, the orchestra; the Chinese Room argument - what of the very human elements of truth/trust/judgement/sincerity in the context of AI.

## Outcomes - directions for future work

1. There are clear humanities applications for rendering spatial audio, for example in audio simulation of historic spaces - not only buildings (as in Kügle's VALSOUNDS project) but settings such as mediaeval renditions of song in a processional situation, reconstructing the ephemeral. Machine Learning has a role in this. IoT audio devices are perhaps an understudied area.
2. A theme developed around "relic-ing" of instruments (a process which could involve the digital), which draws on the discussions of identity, authenticity, aura. This could be the basis for further research as well as artistic interventions. There was also interest in further developing philosophical and theological aspects.
3. We see an energetic, highly creative community of makers and innovators, and users who actively explore boundaries. These aspects of the IoT ecosystem have not been extensively explored in Petras. In particular, how can we develop Responsible Research and Innovation in this context?
4. Topics for Digital Humanities include working with content that is both material and digital, capturing the practices and skills which we associate with our "intangible" cultural heritage, and further exploration through digital prototyping (and perhaps music making) as a research method. What are the relics of the digital?
5. The music "vertical" as a future IoT case study area. Its distinctive characteristics include creative design and application of IoT, an active innovation ecosystem, rapid assembly of complex live systems, and augmentation of instruments. We note the creative industries are a major UK business.
6. A very specific project: we want to turn the aperiodic [Penrose paving](#) in front of Oxford's Mathematical Institute into a musical instrument, and there may be other spaces that we could play with (sic) in this way.

## List of Participants & Speakers

[Steve Benford](#) - Mixed Reality lab, University of Nottingham

[Andrew Cusworth](#) - Digital Scholarship @ Oxford, University of Oxford

[Hongshuo Fan](#) - [PRiSM](#), Royal Northern College of Music

[Karl Kügle](#) - Visiting Professor Utrecht/Oxford, Faculty of Music, University of Oxford

[Graham Klyne](#) - Oxford e-Research Centre, University of Oxford

[Robert Laidlow](#) - Jesus College, University of Oxford

[Sam Salem](#) - [PRiSM](#), Royal Northern College of Music

[Carolyn Ten Holter](#) - Computer Science, University of Oxford

[Julie Yeow](#) - Engineering Science, University of Oxford