Centro di Sonologia Computazionale: 70 Years of Information Engineering and Music at the University of Padua

UNIVERSITÀ DI PADOVA
Dipartimento di Ingegneria dell'Informazione

Department of Information Engineering

CSC Centro di Sonologia Computazionale

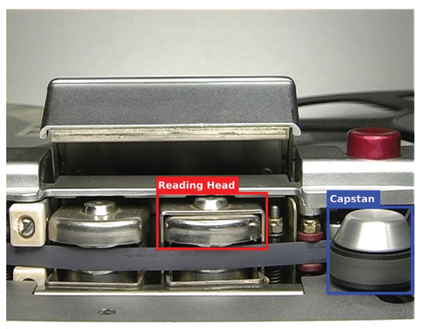
Introduction

From the first computer music systems developed at the CSC to contemporary practices of technologically mediated performance.

The origins of the Centro di Sonologia Computazionale (CSC) date back to the late 1950s. Established as a university research center in 1979 at the University of Padua, the CSC is now one of the leading international references in the fields of computer music, sound technologies, and interdisciplinary music research [1].
Currently directed by Sergio Canazza, Full Professor of Computer Science at the Department of Information Engineering, and with Alvise Vidolin as artistic director, the CSC represents a unique meeting point between scientific research and musical practice. The research team also includes, among others, Antonio Rodà, an international reference in the fields of affective computing and musical cultural heritage preservation, and the former director, now senior scholar, Giovanni De Poli.
Since its inception, the Center has developed at the intersection of engineering and music, creating an environment in which technological innovation and artistic creation evolve in close relationship. Over more than seven decades, its activities have spanned numerous areas, including sound analysis and synthesis, voice modeling, spatial audio, musical expressivity, multimodal interaction, Live Electronics, computational co-creativity, and the restoration of musical heritage. A distinctive feature of the CSC is the central role assigned to musical creation alongside scientific research. Works are not considered merely artistic outcomes, but true experimental devices, capable of testing technological systems and opening new research perspectives. At the same time, scientific models and tools are developed in relation to the perception, performance, and expressive intention of the artist.
Over the years, the CSC has collaborated with major cultural institutions, including the Venice Biennale [2], contributing significantly to the development of electronic music and Live Electronics practices at the international level. Today, it continues to operate as an interdisciplinary laboratory where researchers, composers, and musicians share a common space for experimentation, grounded in innovation, historical awareness, and the centrality of human experience.

Research

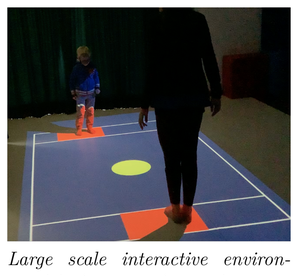
- **Computational tools for audio document and media-art interactive installation preservation**
  Millions of hours of recorded music, environmental sounds, and human voices—valuable traces of past life—are at risk of disappearing. This loss of collective memory is driven by the inherent physical and chemical instability of audio carriers. Unlike paintings or sculptures, which can survive for centuries or even millennia, most audio media have a dramatically shorter life expectancy, often ranging from just a few years to a few decades. Magnetic tapes, for instance, gradually degrade as their binder deteriorates, leading to signal loss and eventual unreadability.
  At CSC, a novel, philologically grounded methodology has been developed to address this challenge, focusing on the preservation and restoration of sound archives, particularly speech recordings and electroacoustic works. This approach has already been applied in major international projects involving institutions such as the Archivio Luigi Nono, Paul Sacher Stiftung, Centro Studi Luciano Berio, Fondazione Arena di Verona, Scuola Normale di Pisa, Teatro Regio di Parma.
  From a computer science perspective, the methodology integrates specialized hardware infrastructure with advanced (AI based) software pipelines. Restoration workflows include high-fidelity digitization, thermal treatment of degraded tapes, and rigorous documentation. Crucially, CSC leverages AI-driven tools for tasks such as discontinuity detection and equalization profiling, enabling scalable and partially automated processing. Beyond preservation, CSC rethinks audio documents access [3] and the reactivation of interactive media-art installations [4].



AI-based software identifies the points of interest in an audio tape.

Michele Sambin's performance within the reactivated interactive installation Il tempo consuma *(2022).*

- **Affective Computing.** In human–computer interaction, emotions are increasingly recognized as a key component for creating meaningful and engaging experiences. Affective Computing aims to model, interpret, and respond to human emotions, enabling technologies that are more adaptive and intuitive. Within this context, music represents a powerful and universal medium for eliciting a wide range of emotional responses and sensory experiences.
  At the Computational Sonology Centre (CSC), research in Affective Computing explores how emotional content can be modeled and generated through sound and music [5]. In particular, the CSC develops computational models for the automatic performance of music with expressive and affective qualities, going beyond mere note reproduction to capture nuances such as dynamics, timing, and articulation that convey emotion. In parallel, the CSC leverages advanced Artificial Intelligence techniques to train multimodal generative models. These models are designed to investigate the relationships between different sensory domains, including music, taste, and smell. By exploring how auditory stimuli can be associated with flavors and odors, this research opens new perspectives on cross-modal perception and creative applications, from immersive experiences to innovative forms of digital interaction.
- **Hardware and software re-activation**
  The rapid evolution of electronic technologies has led to exponential advances in hardware, paralleled by increasingly sophisticated software ecosystems and diverse storage media, such as floppy disks, removable cartridges, and early hard drives. Collections like those of the Centro di Sonologia Computazionale (CSC) preserve invaluable materials on these media, including pioneering electroacoustic works and software for historic systems like the PDP-11 with the CSC-IRCAM 4i Sound Processor.
  To address this, CSC has undertaken a comprehensive preservation effort, digitizing floppy disks, hard disks, and RL02 packs, while also safeguarding original firmware. Low-level disk imaging techniques, custom hardware interfaces, and restored legacy drives enable accurate data recovery and emulation. More complex systems, such as removable hard disks and SCSI drives, require specialized acquisition pipelines and post-processing tools. Beyond data recovery, research extends to computational reusability: deep learning models based on transformer architectures are being developed to translate legacy music programming languages from the 1980s (e.g., Music V) into modern, machine-readable formats. This allows historical code and compositions to be interpreted, executed, and recontextualized on contemporary systems. Together, these efforts not only preserve digital artifacts but also reactivate them, bridging obsolete technologies with current computational environments.
- **Multimodal interaction design**
  Since 2009, CSC has been developing interactive, multimodal educational systems designed to overcome the limitations of traditional static and text-based approaches, particularly in contexts where accessibility is critical. These systems actively engage users through sound and music, combining ease of use for teachers with innovative features such as gesture-based interaction, real-time feedback, and elements of play and competition, which have been shown to improve both engagement and learning outcomes. Research has further explored the use of spatial sonification and haptic feedback to enable non-visual interaction with digital content, for example in applications such as virtual maps for visually impaired users.



Large scale interactive environment to improve visuomotor coordination.

  In addition, auditory feedback has proven effective in motor learning and rehabilitation contexts, supporting performance enhancement and recovery processes. Overall, these studies highlight how well-designed multimodal technologies can transform education into a more accessible, engaging, and effective experience for a wide range of learners.
- **New Music Research.** CSC fosters the creation of music shaped by advanced computer technologies developed in its labs. Here, composers and researchers collaborate closely, treating artistic creation as a process akin to scientific inquiry: experimentation, hypothesis, iteration, and refinement. While commercial tools make technology-assisted music widely accessible, producing truly novel sonic expressions requires custom systems and deep technical expertise. CSC provides both, designing ad hoc tools that enable composers to explore uncharted musical territories. This synergy between art and science extends to public concerts, where experimental works are presented, sharing research outcomes and demonstrating how innovation in music follows the same rigorous, exploratory methods as scientific research. Among the numerous composers with whom CSC has collaborated, it is worth mentioning at least: Giorgio Battistelli, James Dashow, Adriano Guarnieri, Luigi Nono, Nicola Sani, and Salvatore Sciarrino (https://csc.dei.unipd.it/multimedia-works/).
  As an example, PianoSpace is the result of the research for a new approach to the instrumental potential of the piano, up to now limited by the morphological characteristics of the keyboard-hand system. PianoSpace moves away from the piano tradition to explore the sonic potential of the piano and a kinetic control system in space through the creation of multiple Virtual Morphological Models and different Compositive Maps.
- **AI-based co-creativity** Artificial intelligence is profoundly reshaping the concept of creativity, especially in the arts [6]. Today, creativity is no longer seen as an exclusive human property, but as a process that can emerge from interactions between humans and machines. In this context, we speak of co-creativity, where AI does not replace the artist but expands their expressive possibilities. Neural networks do not create "from nothing"; rather, they generate new content by reworking existing data, raising questions about authorship, value, and intentionality. In CSC, AI is not considered merely an automatic tool, but a creative partner that opens new aesthetic perspectives. The real challenge is not to replace humans, but to understand how to integrate these technologies into meaningful and conscious artistic practices.

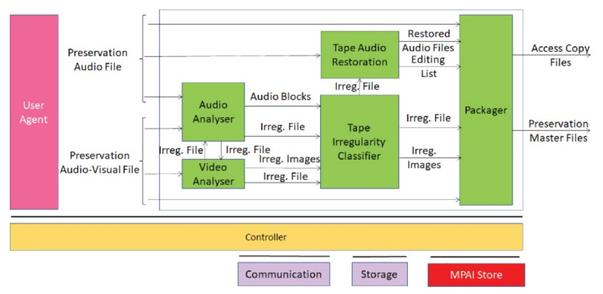
Education

The CSC lab is involved in higher education, taking part in some of the courses as well as PhD Schools at the University of Padua.

- **Computational Creativity, Music Computing and multimedia technologies** – Master degree in Computer Engineering, Department of Information Engineering of the University of Padua.
- **Sound Design and Music Technology** – Master degree course, Department of Linguistic and Literary Studies.
- **Research line in sound and music computing** – Ph.D. in Information Engineering (Dept. of Information Engineering).
- **Principles of Computational Creativity** – Ph.D. in Brain, Mind and Computer Science (Dept. of Mathematics).
- **Audio-visual Technologies** – 1st Level University Master in Science Communication (Dept. of Physics)

Third Mission

The CSC is strongly committed to technology transfer and to communicating its research outcomes to a broad audience. In synergy with the laboratories, the university spin-off **Audio Innova** srl (audioinnova.com) operates as a bridge between research and industry, developing advanced solutions in audio technologies, artificial intelligence, and immersive media for cultural heritage, education, and creative industries. This collaboration enables CSC innovations to move beyond academia and generate tangible societal and economic impact. Audio Innova has also contributed, together with Marina Bosi from Stanford University, to the definition of the **international standard IEEE 3302-2022**. The standard employs Artificial Intelligence to automate the digitization of audio documents and their high-quality coding [7]. Audio Innova received, in both 2023 and 2024, the **Palme d'Or** at the **Neurons Awards Creativity AI Trophy** of the World Artificial Intelligence Cannes Festival (WAICF), one of the major global events in artificial intelligence. It is a founding member of **MPAI** (Moving Picture, Audio and Data Coding by Artificial Intelligence), an international, unaffiliated, non-profit organization developing standards for AI-based data coding with clear Intellectual Property Rights licensing frameworks. CSC's research has led to several industrial patents. Notable examples include:



Standard IEEE 3302-2022 Workflow

- the Pedal Resonance Effect Simulation Device for Digital Pianos (Patent No. 5744743, 1998), which models the complex acoustic behavior of piano strings
- the Method and Device for the Structural Control of Wooden Poles (WO/2016/120774), demonstrating the transfer of signal processing expertise to other domains.

Technology transfer is complemented by product development, such as the BoardOnAir lightboard system for augmented teaching, and by extensive dissemination activities. CSC regularly engages the public through concerts, workshops, summer schools, media coverage, and international events, making complex research accessible and relevant. This integrated approach ensures that scientific advances are not only preserved in academic contexts but actively shared, understood, and applied in society.

References

[1] Sergio Canazza and Giovanni De Poli. Four decades of music research, creation, and education at padua's centro di sonologia computazionale. *Computer Music Journal*, 43(4):58–80, 2019.

[2] Sergio Canazza, Giovanni De Poli, and Alvise Vidolin. When the computer entered the music scene: The collaboration between the centro di sonologia computazionale and la biennale di venezia. *Leonardo*, 57(1):89–94, 2024.

[3] Sergio Canazza, Carlo Fantozzi, and Niccolò Pretto. Accessing tape music documents on mobile devices. *ACM Transactions on Multimedia Computing, Communications, and Applications (TOMM)*, 12(1s):1–20, 2015.

[4] Alessandro Fiordelmondo, Sergio Canazza, and Niccolò Pretto. Reactivating and preserving interactive multimedia artworks: an analog performance from the seventies. *ACM Journal on Computing and Cultural Heritage*, 17(2):1–17, 2024.

[5] Antonio Roda, Sergio Canazza, and Giovanni De Poli. Clustering affective qualities of classical music: Beyond the valence-arousal plane. *IEEE Transactions on Affective Computing*, 5(4):364–376, 2014.

[6] Filippo Carnovalini and Antonio Rodà. Computational creativity and music generation systems: An introduction to the state of the art. *Frontiers in Artificial Intelligence*, 3:14, 2020.

[7] Marina Bosi, Sergio Canazza, Niccoló Pretto, Alessandro Russo, and Matteo Spanio. From tape to code: An international AI-based standard for audio cultural preservation - Don't play that song for me (if it's not preserved with ARP!). *IEEE Access*, 12:152544–152558, 2024.

QR Code

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Website: csc.dei.unipd.it