Sonosphere: A Spatial Music Instrument for Human and Artificial Dancers

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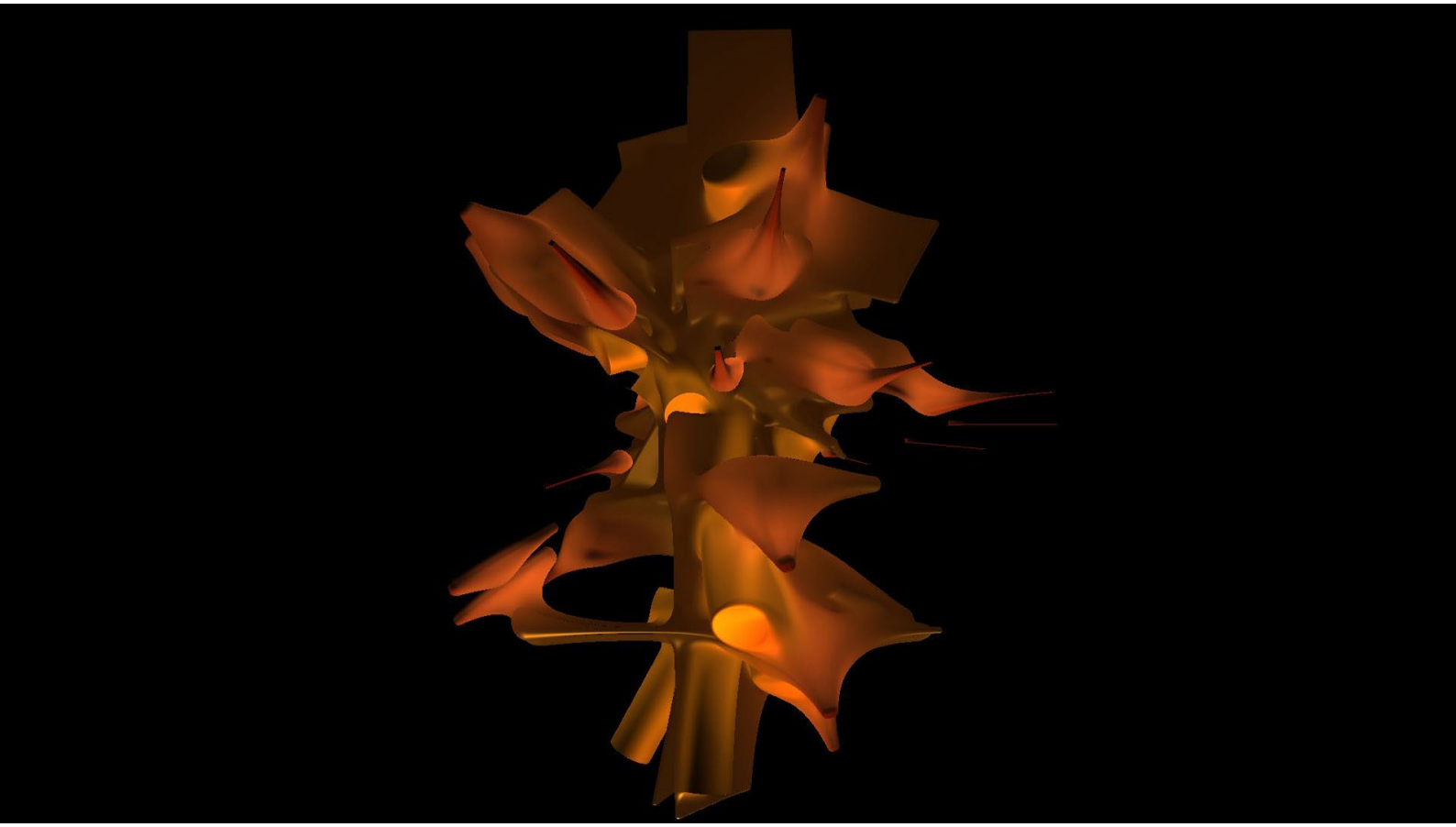

Sonosphere is an artistic tool that functions as a digital instrument, audiovisual installation, and creative platform for realizing and showing new performance works. These performance works bring together contemporary dance, electronic music, computer-generated visuals, and generative AI. As a digital instrument, *Sonosphere* responds to bodily movements, triggering spatially distributed sounds. As an audiovisual installation, *Sonosphere* creates both music and computer-generated visuals that can be interacted with by a visitor or a generative AI, either of which takes over the role of a dancer. As a creative platform, *Sonosphere* offers musicians, media artists, dancers, composers, and choreographers a collaborative space to realize and demonstrate new works. Over the past two years, students and lecturers from the media faculty at Hochschule Offenburg have partnered with a professional dancer to create several pieces for *Sonosphere*. A selection of these works is showcased at xCoAx 2025 in a concert performance.

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Fig. 1. Dance Improvisation with Digital Instrument and Motion Capture. The photo shows a moment during the creation of artistic content for the *Sonosphere*. Several students are observing how the dancer improvises with their audio material while being recorded by a motion capture system.

Introduction

Sonosphere is an audiovisual installation and platform for performance works that combine contemporary dance, electronic music, computer-generated visuals, and generative AI. Simultaneously, *Sonosphere* functions as a digital musical instrument played through dance movements in space. These movements can be generated either by a human dancer or by a generative AI trained on previously recorded dance movements. The mediator between the instrument and the dancing entity is an avatar that is surrounded by a virtual sphere. Sound-generating points are placed on the surface of this sphere. The avatar executes the movements performed by the dancing entity. When these movements bring the avatar's extremities close to the sphere's surface, the sound points located there are activated. The combination of avatar and sound points is made both audible and visible. The activated sound points emit sounds that are generated from recorded audio material. The avatar and sound points are graphically rendered as a unified abstract visual entity.

Over the past two years, students and lecturers at Offenburg University have experimented with this setting in collaboration with a dancer and created several artistic works for the *Sonosphere*. These works are publicly shown for the first time at this year's xCoAx conference in the format of a concert performance. During the concert, the works are remixed in a live improvisation. The improvisation involves the manipulation of the movement-generating AI and the control of parameters for sound generation and graphical rendering.

Concept

Sonosphere establishes an interface between human and machine through which digital representations of musical, visual, and choreographic material can be recombined and made accessible for performative manipulation and reinterpretation. Through the use of a generative AI that creates artificial dance movements, *Sonosphere* can operate with some level of autonomy. As a result, interaction with *Sonosphere* resembles a dialogue-like collaboration. The instrument assumes the role of a partner who shares some authorship with its human counterparts.

One main focus of the work is establishing a creative space where the relationships between the actors and their numerous possibilities for agency manifest in diverse ways. The actors include the choreographer and dancer, who seeks a performative approach to play the digital instrument while simultaneously creating the movement repertoire available to the AI. They include composers, musicians and media artists who define the sonic and visual material and alter the original choreography by manipulating the AI. They also include the installation visitors, who can choose their own roles as passive observers or active participants. Finally, they include the AI which oscillates as a partially autonomous entity between cooperation and recalcitrance towards its human partners.

A second main focus of the work is the adoption of Laban's concept of the *Kinesphere* (Brooks 1993) within the installation. *Sonosphere* establishes a direct link between digital instrumentation and the choreographic principles of spatially expansive dance. In this work, virtual sound points are arranged on the surface of a sphere, with the dancer positioned at its centre. As the dancer traces movement pathways – referred to as "trace forms" by Rudolf Laban – their limbs interact with specific sound points, triggering the playback of corresponding sounds. This interplay fuses physical and musical expressiveness, enriching the dancer's choreography through both movement and sound.

Sound Generation

The sounds are generated using a digital instrument that can be played by the dancing avatar. The instrument consists of multiple sound points distributed on the surface of a virtual sphere (see figure 2). Each sound point is associated with an audio file. The dancing avatar is located at the centre of this sphere and triggers the playback of an audio file by approaching the corresponding sound point with one of its extremities. The number of sound points and

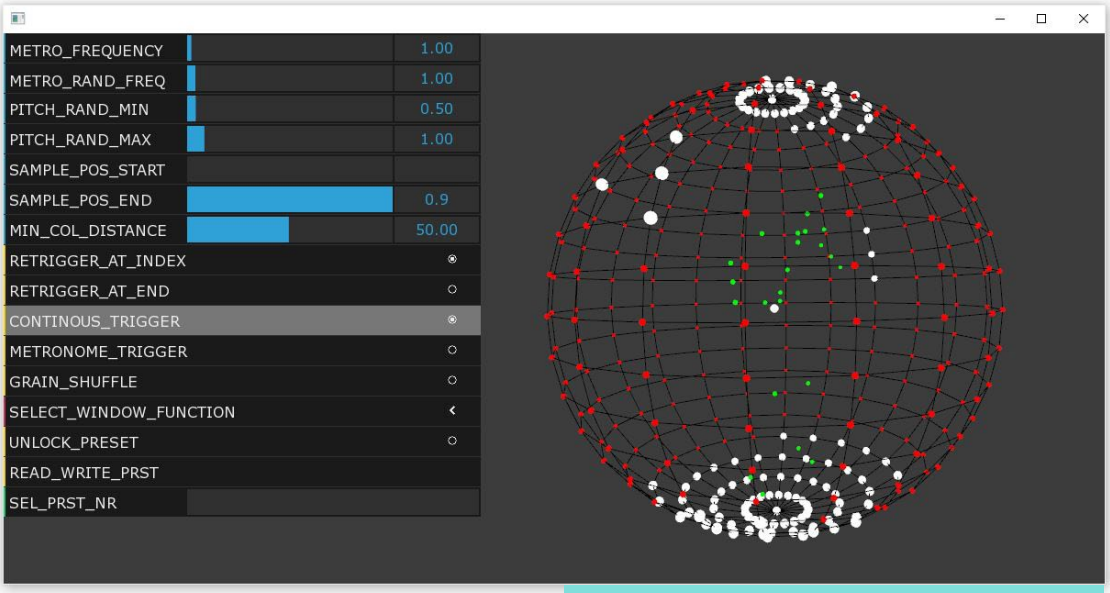

Fig. 2. Screenshot of the digital instrument. The sound points and the dancing avatar are represented as simple 3D visualisation on the right side. In this visualisation, small green dots represent the joints of the dancing avatar, small red dots represent inactive sound points, and large white dots represent sound points that are currently played. The graphical user interface for configuring the parameters for audio playback is shown on the left.

the selection and assignment of audio files to these points significantly influence the performative possibilities of playing the instrument. In some works that have been realized so far, the assignment was executed automatically by sorting the audio files according to chosen audio descriptors. In other works, the assignment was conducted manually. Various options are available for playing the audio files. The audio files can be triggered when falling below or exceeding the minimum distance between the sound node and the dancer. Triggering can occur once or repeatedly, after or before the respective file has stopped playing. The audio files can be played in their full length, as small excerpts, or recombined using *Granular Synthesis* (Roads 1988). The playback speed can be randomly varied between lower and upper boundaries.

Motion Generation

The motions performed by the dancing avatar are either captured live from a human dancer or generated synthetically. In the latter case, a generative AI trained on movement material is employed. This movement material originates from improvisations by dancer Marcella Centenero, which she developed and used for interaction with the digital instrument. These improvisations were captured using a professional motion capture system[1] and used to create a training dataset.

The generative AI employs a neural network model consisting of classical LSTM units (Hochreiter and Schmidhuber 1997). This model is trained using an autoregressive procedure and employs a curriculum learning strategy (Wang, Chen and Zhu 2021). The generative AI learns to predict future dance motions based on a given start motion sequence. These predicted motions represent variations of the original dance improvisation while preserving the improvisation's

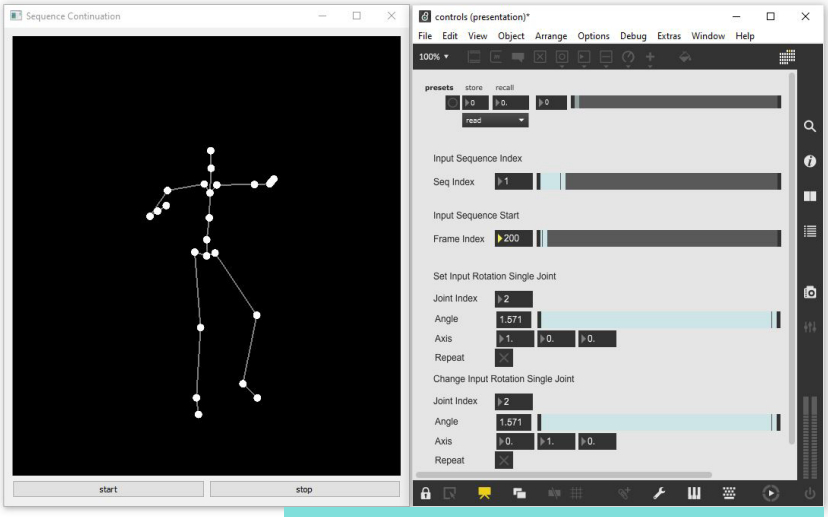

Fig. 3. Screenshot of the generative AI software. The generative AI produces the motion of a dancing figure represented as a stick figure (left side). A graphical user interface allows one to intervene with the motion generation process (right side).

movement repertoire and stylistic characteristics. At the same time, the predicted motions gradually deviate from the original improvisation over a long duration. The deviations manifest themselves as alterations in the temporal sequence of movement motifs, new combinations from different improvisations, a predominance of repetitive elements, and an occasional stagnation. Thus, the AI's motion generation occupies a middle ground between authentically reproducing the original improvisations and autonomously creating new dance motions. The AI operates in real-time, and its motion generation can be interactively influenced. Currently, there are two options for interaction: 1) Selecting a new start motion sequence to be continued by the model, and 2) Overwriting individual joint orientations in the motion sequence used as input by the model. The first option leads to significant changes in the motions generated by the model, while the second option only minimally alters the generated motions.

Image Generation

The avatar and the sound points are made visible as a unified abstract entity by using the Ray marching rendering technique (Tomczak 2012). *Ray marching* is based on the principle of a ray that scans a virtual space for collisions with geometric primitives. The ray is emitted for each pixel of the image to be produced. The geometric primitives are mathematically described as functions that calculate the distance between a point in space and the primitive's surface. The method is computationally demanding, but offers the possibility that primitives can be easily deformed and merged into intricate and seamless surfaces. This possibility can be exploited to vary the appearance of the dancing figure and the sound points and to merge them into a singular visual entity. The appearance can continuously vary between humanoid, amorphous, and platonic forms. The generated image thus conveys the status of the artificial dancer as an entity

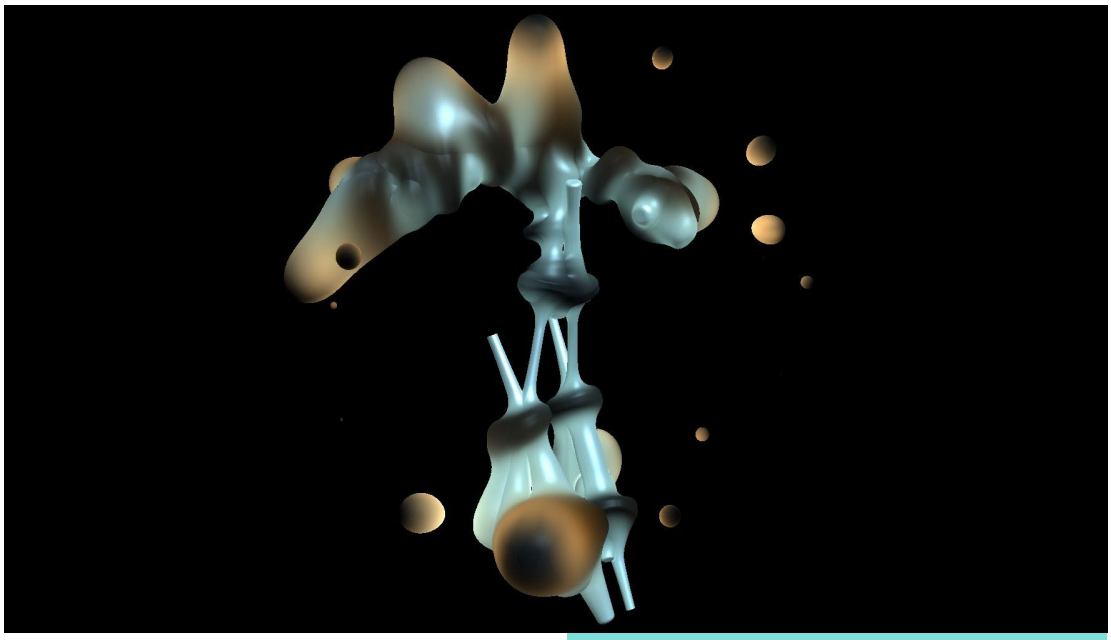

Fig. 4. Screenshot of a graphical rendering of the avatar and sound points. The rendering employs the *Ray marching* technique.

that combines technical-mathematical and natural-human-like properties and merges with the digital instrument in which it is embedded. An example animation is available online.[2] This animation illustrates the rendering of the dancing avatar and sound points using several different parameter settings for the *Ray marching* technique.

Presentation

Sonosphere can be presented at xCoAx 2025 as a concert performance. The musical and choreographic material that provides the content for the presentation stems from several artistic works that have been realized by students and lecturers at the Hochschule Offenburg in collaboration with dancer Marcella Centenero. The titles of these works, their authors, and year of creation are listed in table 1.

Title	Authors	Year of Creation
Dream	Chiara Ehret, Andreas Higel, Maximilian Maurer	2023
Harmonic Orbit	Selina Cuffaro, Alina Engler, Sergej Günter, Nico Neubert	2023
Interface Dance	Magdalena Juarez, Pascal Hohlfeld, Marc Ullrich	2024
Shopping	Habiba Ghanaim, Nicole Stadnik, Selin Öztürk	2024
Music for Human and Object Movements	Ephraim Wegner	2024
Chinese Room	Daniel Bisig	2024

Table 1. Artistic Works. The table lists the artistic works that we realized for the *Sonosphere* by students and lecturers at Hochschule Offenburg in collaboration with dancer Marcella Centenero.

Most of these works are documented with two videos each. One video shows the dancer improvising with the sound sphere while being motion captured. The other video shows a screen performance with the motion-generating AI model as an improvisation partner. These videos are available online.[3]

Concert

During the concert, Daniel Bisig and Ephraim Wegner will re-mix the artistic works that had previously been created for the *Sonosphere*. The re-mix involves the manipulation of the parameters for audio playback and image rendering and the interaction with the motion-generating AI.

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Notes

1. Qualisys Miqus Motion Capture System: https://www.qualisys.com/cameras/miqus/.

2. Ray marching-based Renderings of the Avatar and Sound Points: https://vimeo.com/1056474449.

3. Dream - Screen Performance: https://vimeo.com/1057223470/f09b8c1821.
Harmonic Orbit - Screen Performance: https://vimeo.com/1056476990/5af8a94d59.
Interface Dance - Dance Improvisation: https://vimeo.com/1057564946/d560c59853.
Interface Dance - Screen Performance: https://vimeo.com/1056507731/2fe08ea4a7.
Shopping - Dance Improvisation: https://vimeo.com/1056493554/4a8b3d5139.
Shopping - Screen Performance: https://vimeo.com/1056509177/f4102929bc.
Music for Human and Object Movements - Dance Improvisation: https://vimeo.com/1056498669/cddfc46ed8.
Music for Human and Object Movements - Screen Performance: https://vimeo.com/1057226829/cba53c183f.
Chinese Room - Dance Improvisation: https://vimeo.com/1056504907/0373bb0cbe.
Chinese Room - Screen Performance: https://vimeo.com/1056758658/03bd3901b6.

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