

DEMONSTRATION: A Tangible Pendulum-based Sonic Interaction Experience

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ABSTRACT

Pendaphonics is a tangible physical-digital-sonic environment and interactive system that engages users in individual, collaborative, group, and distributed interactive experiences. The development of this system, as an element of urban revitalization and as a trans-disciplinary research endeavor, presents a strategy for the design and evaluation of a low-cost, flexible, distributed system for public interaction and performance in a large scale tangible system. Pendaphonics has been installed in a public new media arts space, where over 200 people experienced the initial opening of the environment, and is now active within five different research university interaction laboratories. This paper presents the development process and findings from observations and evaluation of Pendaphonics' users and the social interaction patterns among performers and members of the public. In particular, the repeated and sustained invitation to interaction afforded by the cyclic motion of a pendulum's simple harmonic oscillation presents a new tangible interaction scenario for human computer interaction in 3D physical-digital-sonic environments. An investigation of Pendaphonics tangible interaction scenario is articulated along with descriptions of the broad potential of this system as a compositional and choreographic tool, an educational exhibit and classroom manipulative, and as an interface that facilitates playful interaction, exploration, discovery and creativity.

Keywords

Music, Education, Collaboration, Tangible interfaces, Pendulum, Networked performance, Play

1. INTRODUCTION

This paper presents the trans-disciplinary design, development, and evaluation of Pendaphonics, a large scale tangible system that creates and connects interactive physical-

digital-sonic environments for collocated and distributed individuals, pairs and groups. This Pendaphonics installation and environment was developed as part of an urban revitalization effort coordinated by the Platform4 artist collective of Aalborg, Denmark and through a collaboration between new media researchers (musicians, designers, and interaction researchers) from Aalborg University's Department of Media Technology, and Arizona State University's School of Computing and Informatics and Arts, Media, and Engineering program (see www.pendaphonics.com for further information and video demonstration).

2. BACKGROUND

The Pendaphonics system and research agenda is positioned at the confluence of several research communities, (e.g., NIME, CHI, and TUI communities). Related projects that include large-scale interactive musical performance systems and/or public installations include the work of Todd Machover; the Toy Symphony [1], and the Brain Opera [2], among many others such as Tina Blaine's Jam-o-drum [3]. Similar to these, Pendaphonics is an intuitive interface that responds to the natural interaction of both naive and expert users alike. Gil Weinberg has also employed this style of interaction in his Musical Playpen [4] and in his multi-player instrument, Squeezables [5]. The other research area that Pendaphonics centers upon is the domain of responsive environments and interaction design pursued by the HCI and TUI communities. In this respect, Pendaphonics advances agendas of novel interaction paradigms [6][7], the development of robust low-cost ubiquitous and pervasive systems for public use [8], and computer supported distributed collaboration tools [9]. The NIME, HCI, and TUI communities have been actively engaged in creating systems that merge the physical and the digital realm and have found that sonic environments are a particularly rich arena to explore this agenda for advanced media systems [10][11].

3. CREATING PENDAPHONICS

The Pendaphonics system was developed within the broader context of an expansive multi-year harbor and city renovation effort initiated by the Aalborg Kommune, in Northern Denmark. The first installation of Pendaphonics is now a permanent environment at the Platform4 art space in Aalborg, Denmark. It was an invited project for the grand opening in August 2008. We conceived and proposed it as a networked

platform for both soundscape exploration and musical ensemble-style interaction. While this installation is itself distributed throughout the gallery, when remote locations are set up and activated, the Pendaphones becomes a musical link between people around the world. At this time there are Pendaphone systems installed at research locations in Aalborg, Denmark (in the Medialogy program), Arizona State University (in the Motivational Environments research group), University of Oslo (in the Four Ms Laboratory), MIT Media Lab, and at Princeton University (part of the Princeton Laptop Orchestra, PlorK).

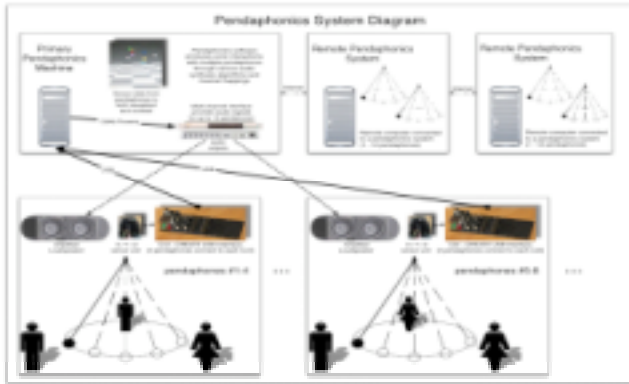


Figure 1: Pendaphonics employs a CPU running Max/MSP/Jitter, video projector with virtual 3D environment, 12 -channel audio interface and speakers at each pendaphone, x-y-z sensors, CREATE USB Interface boards, and tangible bob inviting co-located and distributed interactions.

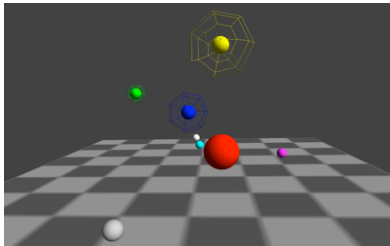


Figure 2: The 3D virtual environment integrates physical, co-located, and distributed interactions, bob trajectories, traces and virtual and temporal structures (e.g. the size of the wireframe around each ball expands/contracts in response to the sound as it is generated), and position updates in real-time.

The primary installation at Platform4 consists of 8 interactive sonic pendulums with low-cost game controller sensors called the Gametrak (<http://www.in2games.uk.com/>) which employ a clever method of measuring the x-y-z coordinates of their motion. The original electronics in the Gametrak was discarded due to its proprietary nature (it only works with some software), and we instead use the CREATE USB Interface (CUI) [18] to digitize the sensor inputs. This provides us with a high-resolution (12-bit) analog to digital conversion and plug-and-play USB-HID (Human Input Device) data format. It is also possible to send Open Sound Control (OSC) format data with the CUI by using μ OSC [19], and we are planning to switch to this in the near future. A single CUI board features 13 analog inputs, allowing four x-y-z sensor units from the Gametraks (i.e. four Pendaphones) are connected to one CUI.

The software for Pendaphonics was created in Max/MSP/Jitter, and a virtual 3D environment (Figure 2) was created both for testing and real-time display of positions and motions of the 8 pendaphones. Participants manipulate a spatial soundscape that is directly controlled by the positions and motions of each of the Pendaphones. Each of the Pendaphones can be raised and lowered between 0–3 meters in height, and the trajectory of their swings directly controls the sounds emanating from a loudspeaker mounted above each Pendaphone. Multiple channels of loudspeakers are used to spatially distribute the sounds that are generated, enhancing the sense of physical immersion in the space. The physical setup is designed to be flexible and can be adapted to many different exhibition spaces and applications.

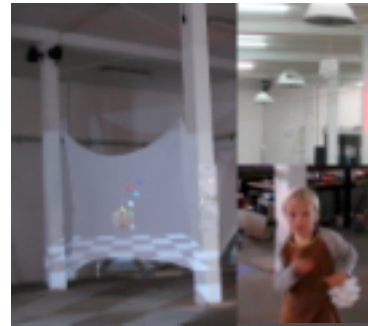


Figure 3, 4, and 5. Left (3), In Platform4's gallery a Pendaphone bob with a projected 3D environment; top right (4), three suspended Pendaphones; bottom right (5), a child plucking the string while holding the Pendaphone bob steady.

The installation exists on multiple levels. At one level it exists as a public installation, where people can walk into the pendulum area and put the pendulums into motion. Another, more complex level has been developed, where musical/sonic games with rules that need to be learned and agreed upon in order for participants to engage. At a third level, the installation can form a space for performance. Here we will discuss the first level.

In the exhibition at Platform4, three different interfaces were implemented. These were all directed towards the intuitive investigation of the interface, where exhibition visitors activate a soundscape in the space. The sound feedback systems have so far been simple and relatively logical. Well known metaphors have been used, such as the idea of the turntable, where a rhythmical soundtrack is played back. Clockwise rotation plays the sound forward, and counter clockwise rotation plays the soundtrack backward; the polar velocity of the swing changes the playback speed. Another sound feedback system consisted of percussion sounds that were mapped to cue points along the 360 degrees of the pendulum swing. Every thirty degrees a percussion sound was activated. The percussion sound changed pitch, depending on how high or low the pendulum was positioned in the air, and the audio frequencies percussion sound was filtered according to the amount of acceleration. The third sound feedback system was a musical piece composed by Mads Weiting (see <http://www.kiloton.dk/>). It consisted of a pre-composed soundscape, where the pendulum movement generated tones that mixed in with the soundscape and varied in texture and velocity.

Pendaphonics has been and will continue to go through multiple design iterations; new physical design solutions and the corresponding interaction possibilities will be explored on an ongoing basis. Each integrated designed solution will encourage new interaction possibilities. To date the following set of interaction frameworks have been explored:

- Sound ball improvisation tool
- Sound transfers and sound traveling (locally and networked), possibly incorporating hanging loudspeakers embedded in the bob, providing natural Doppler and “Leslie” effects
- Diverse ways of throwing and catching sounds through physical actions with the pendaphones
- Plucking the pendulum strings to set up future events or trigger special effects (either sounds or visuals)
- Detection of user’s direct interaction with bobs while the string is motionless, e.g. w/ embedded accelerometers
- Detection of spatial interaction between two or more bobs
- Diverse game/play scenarios
- Individual instruments versus one collective instrument
- Physical vs. virtual presence, movement, and representation

These interaction frameworks certainly have different meanings and affordances, depending on the exhibition context (e.g. section 5 discusses several modalities for Pendaphonics as installation, science, play, choreography, composition and as a distributed network of interactive environments).

4. CONCLUSION

Pendaphonics was developed as a reconfigurable, permanent, public installation, in which individual units, Pendaphones, can be rearranged within an exhibition space to promote the embedded sonic artwork and interaction framework. As such, they can function as a physical platform and gallery installation for multiple sonic artworks that can be exhibited over time or cycled through. Based on the experiences from the public exhibition at Platform4, we are engaged in several new Pendaphonic directions:

- *A musical instrument and performance tool:* Sound and music compositions as well as choreography can be composed, practiced and performed spatially by musicians and/or dancers with the Pendaphonics system. We are actively using the system in these contexts ourselves, and have invited other musicians and choreographers to explore and use the system in their work. A full concert of works composed for Pendaphonics is a near term goal.

- *A math and science manipulative:* Through the elucidation of several mathematical and physical theories that are connected to the movement of a pendulum, Pendaphonics can be experienced in a science museum and/or classroom setting where the sonification of the motions of a pendulum can emphasize concepts that are otherwise difficult for learners to experience and interpret (e.g., elliptical planetary orbits and chaos).

- *A playful tangible gaming interface:* The already rich social interactions that have been observed and the many tangible interactions that have been developed indicate that many types of social games can be developed that leverage any or all of the following parameters: repeated “invitation” to interact, swing direction, angle, speed and acceleration, swing type

(circular or elliptical), swing radius, pendulum height, and plucking of the pendulum strings.

In addition to the importance of the bob design as an enticing interactive tangible object, one of the strongest affordances of the Pendaphonics system is the repeated and sustained “invitation” to interaction that it presents. This invitation is created by the pendulum’s (Pendaphones’) simple harmonic oscillation motion, and its implementation embodies a novel and useful tangible interaction scenario for the NIME-HCI-TUI communities to leverage, through the advancement of 3D physical-digital-sonic environments and related research. Furthermore, the broad range of interaction parameters implemented within the Pendaphonics system can also be utilized to present fine resolution interaction patterns, through which performers and expert users can express themselves, after having extensive practice and/or training with the co-located and distributed elements.

The permanent presence of Pendaphonics in both public exhibits and university laboratories is contributing to the rapid evolution of the tangible and sonic development of Pendaphonics systems. To date, Pendaphonics has been realized as a tangible pendulum-based sonic interaction experience that has been designed to encourage complex dynamic social user interaction with the aim of supporting users to express themselves individually and as members of an interactive ensemble. Through collaborations with domain experts, artist collectives, and institutions the Pendaphonics team is actively engaged in taking the next steps to advance Pendaphonics’ diverse modalities as a: musical instrument and performance tool, math and science manipulative, and a playful tangible gaming interface that promotes inter-generational creative play and discovery.

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