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Sounding Softness and the (Artificial) Subject

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Abstract

The paper discusses the authors' artwork *SONŌ*, its artistic motivations, the artistic research practice underlying its development, and its technical realization. SONŌ is a soft robotics installation that interrogates the interconnections of soft materiality, sound, and subjectivity. It features a sessile soft artificial entity capable of expansive movement, which is ceaselessly sounding itself and various environments using real-time generated audio.

Keywords

Soft robotics, robotic art, soft robot aesthetics, sound art, sound studies, materiality.

Introduction

SONŌ is an artwork featuring a soft pneumatically actuated robot manufactured from silicone. The robot possesses procedurally generated movement and sonification of movements accompanied by a soundscape.

Human and nonhuman animals make utterances that are socially communicative and function to enact a subject position or form connections with other agents inhabiting the environment. The production of sound, whether intentional or unintentional, is arguably a basic existential feat of all living organisms. As empirical phenomena, however, sound by far predates life. In fact, the Universe emerged from what is arguably the ultimate sonic event (which, paradoxically, no one was around to hear) – the Big Bang, cosmology tells us. Sound always originates from a source yet is simultaneously transversal and expansive in character and by nature destined to permeate its surroundings. It is a mediatic phenomenon par excellence – on the material level, sound appears intangible and perhaps as almost nothing in itself, it only exists parasitic to matter, manifesting as perturbations and pressure changes travelling in a physical medium. Sound is characterized by a double movement – it is expansive and enveloping, yet simultaneously local and ephemeral. It is always subject to dampening and seems to evaporate into thin air on the microscopic level, when its waves are converted into heat through friction between the molecules of its medium.

Within the Western tradition of logocentric thinking, one of the ways in which sound comes to matter, is through the privileging of speech over writing [1]. Speech is the primary medium of human thinking and writing is merely a secondary technology. Hence, sound is positioned as the unbridled carrier of being and subjectivity – "I sound, therefore I am". Poststructuralists and their new materialist progeny, however, champion a different position, that foregoes fixity, in favor of flux and the perpetual process of becoming, which is perhaps more adequate to the ontology of sound itself. Here, the subject is considered dynamic and decentered, and the boundaries between self and world permeable. Furthermore, agency is no longer predicated upon subjectivity nor inherent to the subject itself, but a relational dynamism of forces enveloping things as well as environments [2].

Motivation and Practice

SONŌ (Latin: "[I make] sound") explores a nexus of sound, soft robotics, and subjectivity. Through the artwork and its associated practices, we seek to articulate and enact a myriad of complex interactions between these phenomena and their aesthetic and epistemological capture.

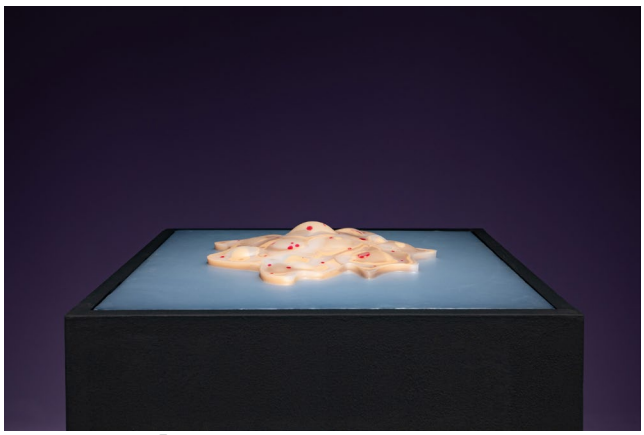


Figure 1. *SONŌ* (2019-2022) (detail), soft robotics installation with 4 ch. sound, variable dimensions (room size). © Mads Bering Christiansen & Jonas Jørgensen. Photo: ZHU Lei.

SONŌ addresses what we take to be basic questions of robotic art in general, including, what does it take to alter or blur the ontological status of an object towards that of a subject, by means of movement and sound? As *soft robotics* (robotic morphologies and components constructed from

pliable and elastic materials [3]) is a key interest of our practice [4]–[12], within the work we were also keen to query connections between soft materiality and sound through robotics as an aesthetic medium. For instance, different kinds of matter are capable of producing impact sounds (via resonance) with specific characteristics in terms of envelopes and frequency spectra [13]. Moreover, materials interact with sound in different ways, e.g., soft materials tend to dampen sound whereas hard materials reflect it.

Figure 2. *SONŌ* (2019-2022) (detail), soft robotics installation with 4 ch. sound, variable dimensions (room size). © Mads Bering Christiansen & Jonas Jørgensen. Photo: ZHU Lei.

SONŌ is influenced by the notion of sound as a *naturecultural* [14] phenomenon. It seeks to consider divergent aspects of the material-semiotic conditions of possibility through which sound and robotic movement can attain agency within specific environments. The physical and physiological properties of softness and ”soft sound” have thus fed into the work, but equally cultural meanings, e.g., notions about sounds made by fictional soft characters from popular culture and cultural associations of softness as aligned with, e.g., precariousness and vulnerability. From the outset, we were thus interested to probe the chimeric character and synesthetic aspects of the concept of “softness”, when used to describe sound and materials respectively. Definitions and delineations of “soft sound” within sound studies, psychoacoustics, and musical theory, were, for instance, drawn upon in our explorations of what might constitute “soft sound” and of the effects of adding “soft” or “hard” sound to a soft morphology.

Part of the artistic research has been conducted in dialogue with the research field of *human-robot interaction* (*HRI*), wherein sound has recently become subject of increasing interest. Our practice sought to be receptive of pressing ideas and questions from this research field and consider how they might gain relevance and be addressed through artistic forms. A body of work within the HRI field has interrogated how various types of sounds can affect people’s perception and interaction with robots and found nonverbal audio to be a salient feature with use potential as a deliberate design aspect of, e.g., social robots. In certain situations and use cases, nonverbal audio is also preferable over synthetic voices, to guide or facilitate interactions with humans [15]. SONŌ adds to this research on robot sound, by exploring how sound and embodiment can interact in soft social robots of unconventional nonanthropomorphic and nonzoomorphic designs, which behaviors that should be accompanied with sound, and what the function of sound might be within these.

The SONŌ Installation

The soft robot morphology was designed to appear organic yet unfamiliar (see Figs. 1-2). Abstract rounded shapes and a hue with similarities to Caucasian human skin, or pig skin, with reddish spotted pigmentations were used. The morphology possesses three independent pneumatic channels. Each of these interconnect four chambers interspersed across it, which can expand when inflated. Ecoflex 00-30 silicone colored with Silc-Pig pigments was used to cast the robot in a 3D printed mold (the robot’s design and fabrication is described in more detail in [16]).

In prior work we have discussed the artistic strategies used to compose the robot’s main sound design (inspired by the sounds made by fictional soft characters in movies) [17], [18]. We have also presented results of an empirical study exploring the effects of different sound designs on people’s perceptions of the robot’s sociality and its interaction affordances [16]. Following these outcomes, work on presenting the project in the form of an art installation ensued[1].

Physically, the SONŌ installation (Fig. 3) consists of:

1. The sonified soft robot displayed on a black plinth (dimensions 112 x 40 x 40 cm.)
2. A set of external speakers mounted in the room

The plinth features a door that can be opened to operate the robot during exhibition and houses the following on three shelves (see Fig. 4): an active loudspeaker, an electro-pneumatic actuation system (microcontroller, motor shield, pumps, valves etc.) and an audio interface, a laptop PC running a software synthesizer. Along all four edges of the plate holding the robot morphology, a small opening is present, to allow sound from the loudspeaker inside the plinth to be

[1] A supporting video showcasing excerpts of the SONŌ robot performing with the robot sound and soundscape is available at: https://youtu.be/U0fGXCbcygU

transmitted to the exhibition space (Fig. 2). The audio of the installation consists of two times 2-channel stereo comprising: 1. robot sound – played over the loudspeaker inside the plinth, 2. a soundscape – played over the external loudspeakers in the room.

Figure 3. *SONŌ*. Installation views at Chronus Art Center (2022). © Mads Bering Christiansen & Jonas Jørgensen. Photo: ZHU Lei.

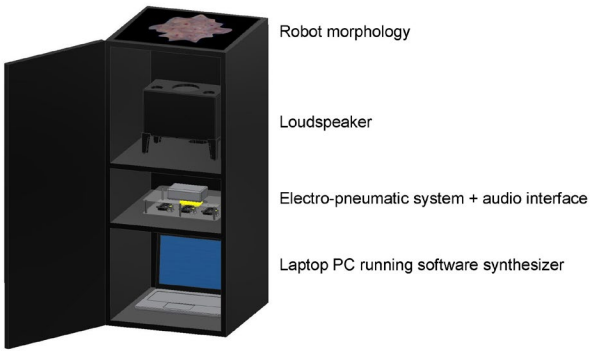
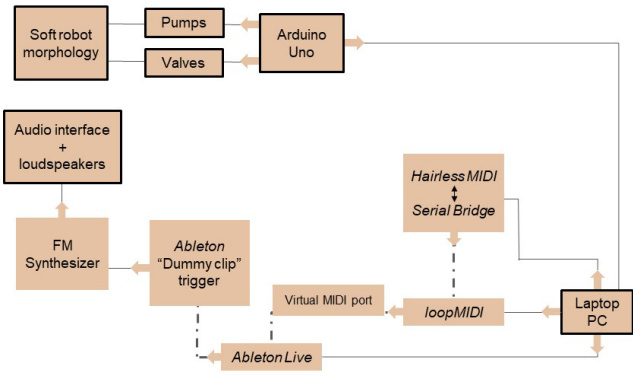


Figure 4. CAD rendering of the plinth showing the equipment inside (shown here with the operation door opened). Illustration: Cao Danh Do. © Cao Danh Do, Mads Bering Christiansen & Jonas Jørgensen.

The Technical System

A diagram of the technical system is shown in Fig. 5 with the signal paths indicated. An Arduino Uno, which controls the robot's movement by activating pumps and valves,



functions as the master with a laptop PC generating the audio running as slave (for details see [16]–[18]). A signal to generate matching robot sound using the FM software synthesizer is sent when a movement phrase is triggered. The robot does not currently have any sensors.

Figure 5. Schematic overview of the technical system and signal paths. Outlined boxes denote physical system components, boxes devoid of outlines are software components. Illustration: Mads Bering Christiansen & Jonas Jørgensen. © Mads Bering Christiansen & Jonas Jørgensen.

Robot Behavior and Sound Programming

For the final installation, we built upon existing code already developed for movement and sound generation. We chose a phrase-based and a categorical approach to designing the robot's behavior. By "phrase" we refer to sequences of robot movement and matching sound of a duration up to 30s. The robot operates as a finite-state machine (FSM) with four mood states (categories). These each correspond to different levels of arousal (relaxed, medium-relaxed, medium-aroused, aroused). In each mood, the robot generatively combines a specific set of phrases and pauses matching this mood. Each of the phrases were hand coded and iterated upon for expressivity (through trial and error) and subsequently matched to one of the four mood states. A total of 13 phrases were used as building blocks that are combined in different ways to generate the robot's movement and sound behaviors. All mood states feature a breath-like phrase with the robot performing asynchronous periodic inflation across the chambers, that use increasing frequencies for increased arousal, in accordance with findings of our prior work [19].

In addition to the robot sound, the installation features twelve composed soundscapes that are played parallelly through Ableton Live. These are also triggered by the microcontroller, but asynchronously with the robot's movements and sound. The soundscapes consist of processed synthesized and recorded sounds and select sonic textures combined into ethereal sonic expressions devoid of temporal structure and timing. The audio was kept spacious and wide to let the robot's more erratic utterances come into focus and only add a more subtle affective coloring of these. In accordance with this, the soundscapes are played over loudspeakers physically separate from the robot's plinth. The soundscapes mix slow extensive sounds to create the aural

impression of an atmosphere of the installation and to position the robot (and its visitors) in different sonic worlds of various affective intensities. Played in random succession, the soundscapes complement or clash with each other, and contribute a sense of emergent narrative.

Further work

We plan to expand upon SONŌ in an updated version of the installation and in subsequent independent works. As a next step, we would like to develop a means to have more interactive generation of the robot and soundscape audio. Currently, the robot switches between its four mood states pseudo-randomly with the statistical likelihood that the robot will switch its arousal state up or down after a completed phrase cycle as an adjustable parameter. We hope to add sensors to the installation, e.g., room scale computer vison, to track activity, behaviors, and affective states of visitors to enable the robot to interact. Furthermore, we are considering developing and validating a more fine-grained phrase-based or parametric generation of affective movement and sound with the system that can contribute more variation and nuance to the robot's expressions.

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