Paper presented at
15th ACM/IEEE International Conference on Human-Robot Interaction (HRI 2020)
Cambridge, United Kingdom, March 23-26, 2020

The Sound Settler: Spontaneous HRI in an Art Setting

Marcel Kaufmann
Polytechnique Montréal
marcel.kaufmann@polymtl.ca

Adrian Zwiener
University of Tübingen
adrian.zwiener@uni-tuebingen.de

Jean-François Robin
Concordia University
jean-francois.robin@mail.concordia.ca

Jean-Pierre Gauthier
Concordia University
jean-pierre.gauthier@concordia.ca

Giovanni Beltrame
Polytechnique Montréal
giovanni.beltrame@polymtl.ca

David St-Onge
École de technologie supérieure ÉTS
David.St-Onge@etsmtl.ca

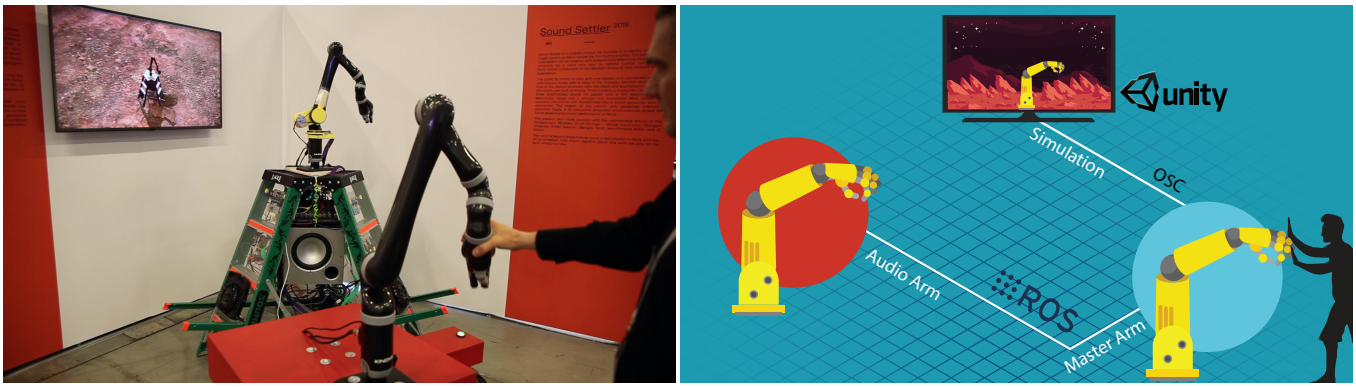

Figure 1: Sound Settler: Artwork (left) and Interaction Concept (right, using designs from macrovector / Freepik).

ABSTRACT

The Sound Settler is a utopian project which combines engineering and the arts. The utopian vision is to deploy an interactive music system on Mars before the first humans arrive. Two real robotic arms are controlled in a gravity compensated master-slave mode resembling the human part on Earth, and the robotic art piece which is envisioned to be located on Mars. The movements generate electronic music by charging physical capacitors and on screen a simulated third arm is deployed, visualizing the movements on the red planet. This report presents the artistic design, the implemented infrastructure and first subjective insights about human interactions with the art piece in public spaces. It motivates a more formal analysis and opens several research avenues for the future.

CCS CONCEPTS

• **Human-centered computing** → **Interactive systems and tools**;
• **Applied computing** → *Fine arts*; Sound and music computing.

KEYWORDS

art; human robotic interaction; trust

HRI '20 Companion, March 23–26, 2020, Cambridge, United Kingdom

ACM ISBN 978-1-4503-7057-8/20/03.
https://doi.org/10.1145/3371382.3378310

ACM Reference Format:
Marcel Kaufmann, Adrian Zwiener, Jean-François Robin, Jean-Pierre Gauthier, Giovanni Beltrame, and David St-Onge. 2020. The Sound Settler: Spontaneous HRI in an Art Setting. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction (HRI '20 Companion), March 23–26, 2020, Cambridge, United Kingdom.* ACM, New York, NY, USA, 3 pages. https://doi.org/10.1145/3371382.3378310

1 INTRODUCTION

As robotic technologies mature and move beyond the boundaries of controlled research laboratories, it is essential to test interactions with humans in real-world scenarios over extended periods of time. Traditionally, it was presumed that mathematical or engineering rigour alone could guarantee successful robotic deployments. However, there are many factors that impact adoption notwithstanding the technical specifications. Public acceptance and important human-centred factors such as dependable and intuitive interaction, trust and usability are central to the successful adoption of robot technologies. Lately, many first-generation social robotics startups have struggled to flourish [10], and obstacles need to be overcome to achieve widespread adoption of robots in non-industrial sectors. There is a clear need for new frameworks and opportunities for studying HRI to address these challenges and to develop a more nuanced understanding of how to promote and enable successful, long-term human-robot interaction [2].

The field of robotic art emerges as a potential proving ground in these regards [9]. Interactive art and live performances present opportunities to situate — and study — robots in real-world settings with real people. Artists have repeatedly shown new and creative use cases for robots that challenge conventional wisdom and, in

the process, become catalysts for advancing the state of the art in robotics. The Sound Settler artistic installation embodies this cross-disciplinary approach with the association of three robotics laboratories, a visual artist and a robotic hardware manufacturer.

The artwork questions the chronology and technology foreseen for extra-terrestrial colonization. For the artist, the first Mars colonization will be musical, with experimental electronic music produced conjointly by a robot arm and its remote human operators. The challenges of this project originated in aesthetics, electronics, and the robotic control. The engineers needed to ensure robustness for large audiences with a sensible sound-based robotic interaction while not interfering with the artistic concept.

2 ARTS AND ENGINEERING

As shown in Figure 1, two robotic arms (Jaco 2, Kinova Inc.) are used in this work. Both physical arms operate in a master-slave mode and are controlled using the Robot Operating System (ROS), while a third arm is simulated using the Unity game engine.

2.1 The artistic concept and challenges

It is the first time that the artist (JP Gauthier) engaged in a high-tech project with robotic arms for which he cooperates with engineers that help him realize this work. Inspired by Panamarenko's [6] futuristic space vehicles and mechanical robots, as well as Tim Hawkinson's large-scale kinetic and sound-producing works [8], the artist created his utopian work for the colonization of Mars. Artists usually work with affordable tools, but this work is blending high-tech robotics, engineering, and the arts. This is what makes this project interesting, says the artist.

The sounds are generated by a remote operator on Earth; a human interacts — almost dances — with a robotic arm (master arm). These movements get sent to a second robotic arm which is mounted on a do-it-yourself landing platform, which is an homage to Tim Hawkinson's works in which everyday objects are transformed into machines. The robotic arm on this platform differs from the input arm as it is equipped with external dynamos that charge capacitors for the musical performance. As these capacitors discharge electronic sounds are generated and so the physical movement of the arm is translated into sound. Tinguely's kinetic sculptures [1] are an additional inspiration for this work. Other artworks that are in line with the Sound Settler include Robotlab's "big picture" [5] which uses a robotic arm to draw a Martian landscape, but in a non-interactive way, and Outrace [7] which uses light to write messages chosen by the public into the air.

For the users to experience the musical composition, the second arm is located close to the first one. As for the extraterrestrial deployment, a simulated third arm is placed in a virtual Martian landscape using a computer simulation generated in Unity. This virtual arm brings the Sound Settler to Mars and humans that interact with the artwork can see how their actions on Earth manipulate the second robotic arm that generates sounds on Mars.

2.2 The robotic control

The robotic arms are set up in a master-slave configuration that builds a coupled system with the human operator. The human feels an admittance contribution Y as a result of the robot dynamics and the human has an impedance Z that has an effect on the robot arm itself. A comprehensive review on admittance control is given in [3], but in general, a force that describes a motion control reference or a change from such reference is used as a measurement for admittance and impedance control. The original admittance control of the robotic arm [4] is paired with gravity compensation and a robotic driver that allows admittance update rates of up to 65 Hz. Figure 2 depicts the inter-dependencies of the robot in admittance mode, the human operator, and the PD-controlled slave arm which is used to generate the sound of this artwork while omitting the gravity control for simplicity. The human voluntarily applies a force F^*, while human body dynamics act with an internal force F_{int} on the system. The total external force experienced by the robotic arm F_{ext} is the sum of these forces. As a result of the admittance control and human forces, the robot arm is moved to a new position p. This p is then used as a set-point for the PD-controller moving the audio-generating arm in a velocity-controlled mode towards its target position. These target positions are also sent to the virtual arm within the Unity simulation using an OSC (Open Sound Control) interface as illustrated in Figure 1.

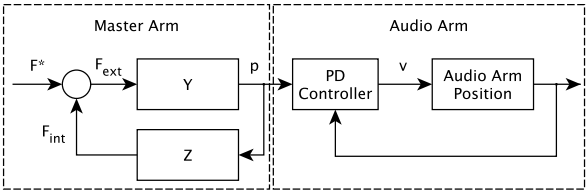

Figure 2: Relation between admittance controlled master robot, the human and the audio arm.

3 INTERACTION OBSERVATIONS

The artist was fascinated by how smooth and fast he could interact with the robotic arms of this installation — almost as if he was dancing with a robot and thus composing the soundtrack that resembles the first steps toward a human settlement on Mars. A realistic communication delay between Earth and Mars has been neglected (so far) to show the audience how their choreography looks and sounds on Mars.

During two exhibitions (ICRA and Elektra 2019) people had the chance to interact with this work. Some were shy and interacted with the installation only briefly, while others played around for several minutes and explored the interactive motion between their own interactions and the system that they now had become part of. Once assured that they are indeed allowed to touch this robot, the audience seemed to trust it and was not afraid of any harm as they were in control of the movement.

4 CONCLUSION AND FUTURE WORK

The Sound Settler resembles an interaction between the arts, engineering, robots, and humans. The combination of high- and low-tech elements lets the curious humans explore the motion through the audible feedback of the artwork. Future work will exploit this element to study the user's perception of the arm's trajectory performance. It could also be extended to exploring the impact of high communication latencies on trust in teleoperated robots that generate sound. The Sound Settler showed how it can be deployed for

large audiences and the successful exhibition of this work motivates a quantitative analysis of the spontaneously emerged HRI.

REFERENCES

[1] Museum Jean Tinguely Basel., Jean Tinguely, Niki de Saint-Phalle, Pontus HultÈn, and Margrit Hahnloser-Ingold. 1996. *Museum Jean Tinguely : the collection.* Benteli Publishers, Berne.

[2] Malte Jung and Pamela Hinds. 2018. Robots in the Wild: A Time for More Robust Theories of Human-Robot Interaction. *ACM Trans. Hum.-Robot Interact.* 7, 1, Article 2 (May 2018), 5 pages. https://doi.org/10.1145/3208975

[3] Arvid QL Keemink, Herman van der Kooij, and Arno HA Stienen. 2018. Admittance control for physical human–robot interaction. *The International Journal of Robotics Research* 37, 11 (2018), 1421–1444. https://doi.org/10.1177/0278364918768950

[4] Alexandre Lecours, Boris Mayer-St-Onge, and Clément Gosselin. 2012. Variable admittance control of a four-degree-of-freedom intelligent assist device. In *2012 IEEE International Conference on Robotics and Automation*. 3903–3908. https://doi.org/10.1109/ICRA.2012.6224586

[5] Jan Zappe Matthias Gommel, Martina Haitz. 2014. The big picture. http://www.robotlab.de/thebig/picture_en.htm Accessed: 2020-01-08.

[6] Panamarenko and Hans Theys. 1992. *Panamarenko.* Internat. Ed., Tervuren.

[7] Clemens Weisshaar Reed Kram. 2010. Outrace. http://www.kramweisshaar.com/projects/outrace Accessed: 2020-01-08.

[8] Lawrence Rinder, Howard N. . Fox, Doug Harvey, N. Y.). Whitney museum of American art (New York, and Los Angeles County Museum of Art. 2005. *Tim Hawkinson.* Whitney Museum of American Art ; Los Angeles County Museum of Art ;, New York; Los Angeles; New York : distributed by H.N. Abrams.

[9] D. St-Onge. 2019. Robotic Art Comes to the Engineering Community [Art and Robotics]. *IEEE Robotics Automation Magazine* 26, 3 (Sep. 2019), 103–104. https://doi.org/10.1109/MRA.2019.2927198

[10] Mariya Yao. 2017. Why Building Social Robots Is Much Harder Than You Think. https://www.topbots.com/building-social-robots-jibo-anki-cozmo-much-harder-think/ Accessed: 2019-12-10.