Creating an interactive and accessible remote performance system with the Piano Machine

Patricia Alessandrini, Constantin Basica, Prateek Verma

Center for Computer Research in Music and Acoustics – CCRMA, Stanford University

patricia@ccrma.stanford.edu, cobasica@@ccrma.stanford.edu, prateekv@stanford.edu

Abstract. This demo shows a work-in-progress development of an intelligent interactive system for the Piano Machine, a physical computing system that causes the strings of the piano to sound through mechanical excitation. While the first version of the Piano Machine, developed in 2017 by Patricia Alessandrini and Konstantin Leonenko, employed a simple midi-keyboard control using Aftertouch for continuous control, the Piano Machine was further developed in 2019-2020 with Machine Learning to allow for higher-level control, allowing the Piano Machine to respond interactively to inputs such as live sound and gesture. The current development will integrate the Piano Machine into AI-driven co-creative systems, such that performers/improvisors can use a variety of inputs in-person or remotely. By expanding inputs – ranging from text to gesture, tapping or humming – and providing remote access through a browser-based environment, this system will increase access to musical experiences with the Piano Machine, including for Disabled and/or non-expert music-makers.

Keywords: #Accessibility #Network Performance #Artificial Intelligence

1 Employing AI for inclusive interaction with the Piano Machine in remote or in-person music-making

This project endeavors to bring greater accessibility to music-making with the Piano Machine for both Disabled and/or non-expert music-makers by creating an expressive, dynamic and responsive generative music system that allows a performer to dialogue and interact in real time with the Piano Machine. The Piano Machine - a "robotic" physical computing device designed and created by Patricia Alessandrini in collaboration with Konstantin Leonenko in 2017 - plays the strings of the piano directly through mechanical, sustained vibration created by a set of motors and finger-like appendages controlled by microprocessors, thus creating dynamic control of notes over time [1]. Control data for the Piano Machine will be generated in real time using AI models to interpret a range of different inputs – including text, gesture, tapping and humming – to create an environment for accessible creative music-making, including composition and improvisation.

The use of accessible inputs is based on research performed by Prateek Verma, Constantin Basica, and Patricia Alessandrini principally over the past year [2], with financial and institutional support from Stanford Human-centered Artificial Intelligence (HAI), the Stanford Humanities Changing Human Experience Grant project *Considering Disability in Online Cultural Experiences*; the EU Horizon project Multisensory, User-centred, Shared cultural Experiences through Interactive Technologies (MuseIT); the Center for Computer Research in Music and Acoustics (CCRMA); and the Institute for Research and Coordination in Acoustics/Music (IRCAM), particularly through its European Research Council (ERC) Project REACH: Raising Co-creativity in Cyber-Human Musicianship.

2 Piano Machine developments to date

2.1 A MIDI-based instrument for direct control in performance

The first Piano Machine was built in the Hatch Lab at Goldsmiths, University of London, with funding from the Arts Council of England (ACE). It was commissioned by Explore Ensemble for the première of *Tracer la lune d'un doigt* [3] at the Huddersfield Contemporary Music Festival (HCMF) in 2017 as well as for other new repertoire [4].

To facilitate composition, notation and performance in varying compositional contexts, the first Piano Machine was controlled by a MIDI keyboard, with Aftertouch used to independently control the post-attack intensity of each note. As the midi-messaging is handled by a micro-computer, no computer is required, only a (USB) MIDI keyboard.

2.1 Voltage handling and playing mechanism

As illustrated in Figure 1 below, the original Piano Machine uses an external voltage source to power individual motors with added appendages – with one motor per piano note - while the voltage sent to each individual motor is determined by the MIDI messages received by the Raspberry Pi, including polyphonic pitch, attack and Aftertouch.

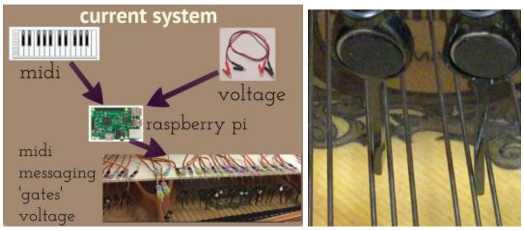

Fig. 1. Voltage and control data flow in the original Piano Machine, with a close-up of the motors and appendages forming the Piano Machine playing mechanism.

The playing mechanism consists of small, cell phone “pager” vibration motors equipped with laser-cut appendages suspended between two piano strings of the same note (or just next to low notes with a single string), which only touch the strings when voltage is sent to them (Figure 1). It is thus possible to play the piano using standard techniques without any interference while the Piano Machine is installed.

2.2 Higher-level control of the Piano Machine

The 2019 version of the Piano Machine was created for *Ada’s Song*, in which it is controlled in realtime using AI processes [5]. It has up to 96 notes (instead of the original 64), wireless OSC messaging, improved stability of the appendages leading to better tone quality, finer dynamic control, lighter weight, better adaptability to different pianos, improved stability, better cushioning and portability, as well as gestural control.

Fig. 2. The new Piano Machine, pictured in rehearsal at The Warehouse, London, October 2019

3 Developing accessible inputs for the Piano Machine

3.1 Integrating text inputs into the Piano Machine

Building on Basica et al’s previous work using AI models to respond generatively – both online and in-person – to text inputs using language models trained with tagged musical data sets such as MTG-Jamendo [2] [6], in the course of 2022-23 these generative music systems have been furthered developed in collaboration with IRCAM, to further elaborate on the melodies generated by the models with the Somax2 system, which can be stylistically trained using music provided or chosen by a participant. While much of this work to date has been workshopped and performed using a Disklavier, the Piano Machine's capacity for continuous control will allow for greater expressivity.

3.2 Humming, tapping and gesture for music-making

In 2022-2023, collaborative co-design workshops organized as part of the Considering Disability in Online Cultural Experiences project have explored a range of inputs to be interpreted into musical outputs by AI models, particularly for potential music-makers who may have limited language use and/or prefer humming, tapping or gesture. Humming and tapping can both be translated by AI models into music, and sonically integrated into improvisations [2]. Integrating humming and tapping, along with the existing gestural control, will thus offer more options for defining musical materials for non-expert music-makers.

4 Remote music-making with the Piano Machine

The goal is to allow the above inputs to be transmitted remotely to the Piano Machine, which will then be live-streamed to the participant(s) using the low-latency, uncompressed audio environment JackTrip (7).

References

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