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Electrifying Opera: Amplifying agency for opera singers improvising with interactive audio technology

Colloquial Paper

Video of presentation can be found here

Electrifying Opera: Amplifying agency for opera singers improvising with interactive audio technology

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Abstract

This research project examines the technical, physical and pedagogical challenges that opera singers face in relation to the use of interactive audio processing technology in opera. It investigates acoustic and aesthetic conflicts between opera and electroacoustic music, explores reasons why opera singers have been slower than classically trained instrumentalists to embrace new technologies, and asks what types of sound design and interactive systems might reduce some of the barriers opera singers encounter in relation to the innovations of the digital revolution. The primary question driving this research is the following: What technical and aesthetic issues need to be addressed so that opera singers can incorporate the use of audio processing technology and improvisation in their performance practice?

Keywords: Opera, Sound design, Audio processing, Embodiment, Live interfaces, Sensors, Augmented instruments

Introduction

In October 2019 I began a PhD in Artistic Research at the Oslo National Academy of Art in the Opera department. My topic of research - Electrifying Opera: Amplifying agency for opera singers improvising with interactive audio technology - focuses on ways to incorporate audio processing into opera while maintaining the primacy of the acoustic voice and the agency of the performer. As a composer and classically trained singer, I have created numerous concert works that utilize live sampling and real-time audio processing. My attempt to create similar work for opera revealed challenges specific to the genre as well as some inherent conflicts between opera and electroacoustic music that need to be addressed.

Operatic technique focuses on developing a virtuosic voice of extended pitch and dynamic range able to project in large spaces without amplification. Opera singers are in effect playing to and with the acoustics of the space. Electroacoustic music on the other hand is dependent on amplification through loudspeakers, and with contemporary sound design one has the ability to digitally simulate different types of acoustics independent of the physical space. The design of traditional opera houses, which optimizes the un-amplified voice, presents acoustic and structural challenges for live electronic processing in opera. Additionally, the orchestral pit inhibits both sight lines and audibility between the orchestra and the singers and sets up a divided acoustic space. When electronic sound is used in traditional opera houses it can create a strange aural disconnect if the electronic sound is coming from mounted speakers that don't blend well with either the orchestra or the singers. The role of the singer as actor and the need for mobility in the space further complicates the creation of work that utilizes performer controlled live audio processing.

Purpose of the research

Nina Sun Eidsheim (2015) theorizes an expanded unpacking of what music consists of, where aural, tactile, spatial, physical, material, and vibrational sensations are all important elements. Regarding opera, Eidsheim writes that "... the unamplified power of the singers´ voices is part of the fetish that defines the artform."[1] Composer Hildegard Westerkamp asserted in a keynote speech at Invisible Places 2017: "sound experienced, produced and received as a physical process can be an effective counterbalance to attempts by commerce and technology to transform it into product and commodity." She elaborated further "One´s own sound output or creative expression not only lessens the authority of externally imposed voices but also offers a new voice of vitality and energy."[2] This foregrounding of vibration and physical process by both Westerkamp and Eidsheim highlights the fact that sound always occurs as an action and vibration within a specific acoustic setting, and that these actions and vibrations *do* something to both the sound-maker and the listener.

In opera the unique "something" - the *doing* that defines it - is the direct, unmitigated transmission of sonic vibrations from the singer´s body to the listeners´ ears. Operatic singing is both intimate and athletic, vulnerable and awe-inspiring, and somewhat magic. Unlike instrumentalists, who can be seen engaging in sound producing actions with their instruments, with singers only their sound supporting actions (movements for breath and articulation) are visible to the audience. The singer´s actual sound producing actions (air vibrating the vocal folds) are invisible. With the addition of language the singer embodies a role of both musician and actor. As a result (and in part because the singer´s sound producing actions are invisible) the singer´s body and hands have heightened semantic value; movements and actions are perceived in a theatrical context. In opera the singer´s movements and spatial location are also significant compositional and theatrical elements of the performance. All this complicates the question of controllers.

Many vocalist-composers, like myself, have been working with interactive technology and custom built controllers to expand the options for vocal expression. Both Franziska Baumann and Imogen Heap have designed sophisticated custom-built midi gloves and wearable controllers using a variety of sensors.[3] Pamela Z has developed multiple controllers, from those measuring electromagnetic signals of muscle contractions, to motion capture, to her most recent system incorporating sonogram technology.[4] Dafna Naphtali has designed an interactive system for controlling a GuitarBot and robotic percussion instruments using a hand held Wii controller.[5] Anne Hege has used a tether controller to process audio using the Wekinator interface. Although these vocalist-composers use their controllers to trigger sound processing in real time via gesture, they maintain a largely stationary position near the computer that is running the audio processing programs. This is partly a function of the type of controllers, but also, and perhaps primarily, a function of dependence on a visual interface to monitor the live audio processing. In concert settings this is unproblematic, but in opera, the dramatic implications of scenography, movements, gestures and costume must all be taken into account. Standing behind a computer and processing audio may be neutral in concert, not so in opera.

If the voice is to be used as a sound source in live interactive audio processing and real-time sampling, it necessitates capturing the vocal input with a microphone. Common practice for most vocalists currently using live electronics has been to amplify the voice simultaneously and mix the amplified voice with the electronic sound, matching the vocal volume level to the volume of the electronic signal – a similar principle of sound design as in rock, hip-hop and pop music. In opera, however, this design robs both performers and the operagoer of one of the primary characteristics and thrill of this genre: experiencing the power and beauty (or fetish) of an embodied unamplified voice resonating an acoustic space. Amplification also adds other potential problems to opera: loss of spatialization, loss of full dynamic range, and distortion of vocal timbre, especially in the higher ranges. The extreme dynamic and register range of the operatic voice presents challenges.

In this research project I am exploring strategies to deal with the issues outlined above. My goal is to design an electroacoustic interactive system for a new opera I am composing that will foreground and accommodate the unamplified virtuosic voice of the operatic singing-actor. The challenge remains to design an interactive system that can accommodate mobility in a dramatic performance, and where the choice making of the performer can be based on aural rather than visual cues.

Methods

Working together with computer engineers, a research assistant and opera singers recruited to be part of a voluntary Participatory Design Group (PDG), various configurations of real-time interactive processing and sound design systems are being tested to address the following questions:

> 1. How can we create a performer driven interactive audio system for opera singers that addresses their needs for physical mobility, dramatic coherence, and performance in an acoustic environment suitable for the unamplified virtuosic voice?
>
> 2. What kind of interactive systems, controllers and mappings might best enable opera singers to enact performer driven control of audio processing, and can we discover best practices through participatory design?
>
> 3. Since the ability to improvise is integral to the use of interactive systems, what types of training should be developed to re-introduce the practice of vocal improvisation to the field?

Based on initial research of existing systems, I am exploring what might be most suitable for controllers designed for opera singers, keeping in mind acoustic and mobility needs. I wish to design a system that can accommodate common embodied performer motions: hand gestures, the motions of handling a prop, playing an accompanying instrument, or engaging with a costume or piece of the set. I have begun to evaluate controllers and mapping options by testing them first myself as a performer, and subsequently with members of the Participatory Design Group. The Wekinator, an open source machine learning software created by Dr Rebecca Fiebrink,[6] is one of the machine learning options I am investigating. The Wekinator seems well matched to the aims and design processes for this research as it allows for rapid prototyping and exploration of mapping options through human-machine interaction, using the computer as a partner. It allows anyone to use machine learning to build new interactive systems by demonstrating human actions and computer responses, instead of writing programming code. It does not require extensive programming skills, but rather enables performers to create mapping through embodied interaction.

Electrifying Opera is a transdisciplinary research project. It spans the fields of operatic performance practice, interactive computer music and composition, sound design, machine learning and the emergent field of active acoustics. It also intersects with costume design and scenography. As a composer and a singer I am drawing on multiple modalities to investigate and develop innovative possibilities for opera singers to augment their voices with performer controlled interactive audio technology. Methods used include workshops in vocal improvisation, participatory design of data mapping, machine learning, prototyping, sound design, signal processing and musical composition. Documentation will include written logs, video and audio documentation. The final artistic application and outcome of this research will be to incorporate my custom designed interactive system into a newly composed chamber opera. A collaboration with librettist/designer Julian Crouch and the Ethos Percussion Group (both based in New York City) forms the basis of the external creative team for this newly composed opera, working title: *The Sailmaker´s Wife*.[7]

Description of the proposed approach

In this research I am exploring how various conceptions of sound design and real-time interactive processing systems can address some of the inherent tensions between opera and electroacoustic music. In regards to sound design, it is possible to capture vocal input without simultaneously amplifying the voice, by sending the vocal signal to the DAW pre-fader for audio processing, and then only amplifying the processed sound. One can thus combine both the embodied unamplified voice and the disembodied processed vocal signal as two separate instruments converging in one space, utilizing the room itself as a common resonator. Starting from the aesthetic point of view that electronic sound in opera should accommodate the acoustic singer rather than the other way around, I am investigating various strategies for the diffusion of electronic sound that would facilitate this, including localized loudspeakers, loud speakers embedded in scenography or costumes, active augmented instruments, and non-standard multi-loudspeaker diffusion systems (NSML systems). Although NSML systems are expensive and probably will not be directly applicable to my final artistic project, the concepts in the sound design offer many new possibilities for the combination of acoustic and electronic sound production.[8]

Localized loudspeakers parallel the way bass and electric guitar personal amps function in an acoustic jazz ensemble. David Lang did this in his recent “*Three Mile Opera*” where singers performed on a 3-mile stretch of an elevated former train line and were paired with their own individual loudspeakers. In her opera “Agora”, Natasha Barrett used live electronics to turn an installation of membranes and aluminium bars into computer controlled mechanical acoustic instruments that mixed with electronic sound from multiple speakers. Long-term collaborators, singer Julie Wilson-Bokowiec and composer Mark Bokowiec have produced works where the performer, outfitted with multiple sensors and controllers, is placed within a “sensitized” performance space, a surround sound system of multiple speakers. Tod Machover has designed Hyperinstruments and sound producing controllers that invite the public to participate in collaborative music making in his operas. And composer-vocalist Pauchi Sasaki has designed a speaker dress[9] – a costume built of multiple small speakers that allows for mobility and localizes all the electronic sounds to her body. I have previously used both localized speakers (custom-built hemispherical speakers) and active augmented instruments in my work. In my opera *The Trials of Patricia Isasa* I used an upright piano with transducers mounted on the soundboard, as a loudspeaker. All the electronic sounds were played through this acoustically active augmented piano, allowing the electronic sounds to be localized in the pit with the rest of the orchestra and blend acoustically. I will continue the exploration of acoustically active augmented instruments to project sound. The exploration of the sound design, like the exploration of controllers, will include singers from the Participatory Design Group. A number of workshops are planned to test out excerpts from *The Sailmaker´s Wife* using these strategies.

Designing an interactive system that can be controlled "blind" necessitates determining both what types of audio processing can be mapped to clear and simple actions, and determining the number of parameters that can be held in mind without visual reminders. Investigating the types of choice making and audio processing that instrumentalists commonly trigger with controllers that facilitate signal processing without a visual interface (like pedal boards), I am testing possibilities for similar choice making with controllers that allow for mobility in the space. Working with singers from the Participatory Design Group I observe how they interact with various controllers, and how they respond to various types of audio processing parameters. Controllers that have been tested to date are the Leap Motion Controller, a smart phone, the HotHand ring, and most recently - following the recommendation of Tone Åse who performed with it at the ICLI 2020 conference - Genki´s Wave ring.

Expected Contributions

This research contributes to the development of emerging technologies in opera, to the development of the improvisational performance skills needed to engage with those technologies, and to the development of innovations in interactive sound design conducive to opera. Based on conversations with other opera composers and with opera singers, I believe there will be significant interest in this research.

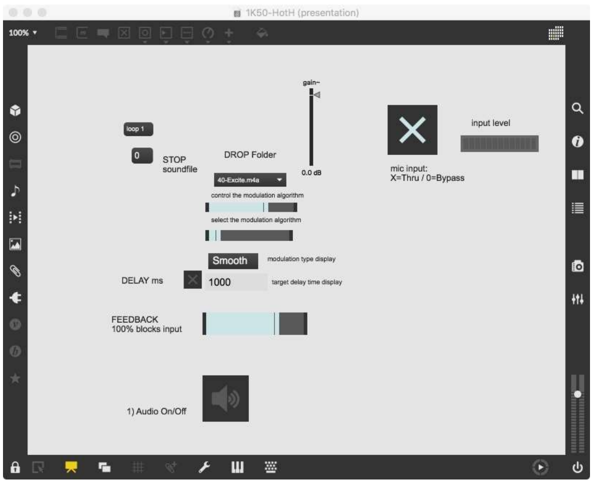
Looking at some of the technical and aesthetic issues that need to be addressed so that opera singers can incorporate the use of audio processing technology in their performance, I expect to address three things in particular that I think will contribute significantly to the field: 1. Determining what types of controllers can address both the theatrical context and the need for mobility. 2. Designing an interactive system that is not dependent on a visual interface. 3. Designing a sound diffusion system that can accommodate both the acoustic unamplified voice and processed electronic sounds. Of these three, I expect that the second may be the most challenging. It may also yield some unexpected pedagogical insights.

Progress towards goals

My research is in its initial phase. I have been corresponding with composer and performer colleagues, reviewing relevant documents and conducting an overview of interactive systems and controllers currently in use by composers working with live audio processing. I conducted initial experiments with an acoustically active augmented instrument – an antique taffelpiano – experimenting with it as both a loud speaker (with transducers) and as an augmented resonator (with contact microphones) that could be used in combination with the unamplified voice and processed audio created through real-time sampling and processing of the voice. I will continue to experiment with augmented instruments of different sizes (zithers, guitars, found objects) as alternative loudspeaker options.

The main focus in this part of my research has been on interactive patch design and controller mapping. I have designed several prototypes for interactive patches in Max and have been testing their suitability for remote control without reliance on a visual interface. With help from my research assistant Bálint Laczkó, various controllers have been mapped to these patches. We have experimented with the Leap Motion controller, smart phones, and a wearable sensor: the HotHand ring, which relays data from a 3-axis accelerometer. The range of motion that the Leap Motion controller is able to detect was too limited to enable mobility. Using a smart phone gave stable data but was awkward physically. For the presentation of this Colloquial paper at the ICLI conference in Trondheim, March 11, 2020, I settled on the HotHand ring, mapped to control 4 basic functions within a real-time vocal sampling and audio processing patch in Max. The four parameters were audio on/off, delay speed in milliseconds, feedback level, & signal bypass. My goal for the ICLI conference presentation was to get the mapping and gesture control stable enough to do a short vocal performance that included live sampling and audio processing while moving in the space, and without relying on the visual interface of the laptop. Two workshop sessions with one of the opera singers in the PDG confirmed that with the mapping we had programmed, control of these four parameters could be fairly easily learned and reproduced with the HotHand ring.

The patch I used for the ICLI presentation required some set-up in advance. It allowed for processing of soundfiles as well as the live signal, but the sound files need to be loaded and preset to a loop function if that option was to be accessed. The recording function for the live signal also needed to be set, as well as the type of modulating algorithm, and the degree of modulation. The modulation algorithms - designed by David Gamper years ago for an earlier interactive patch of mine - determined the amount and type of pitch shifting according to the interplay of delay time and feedback level. With higher feedback levels the sampled material continues to be modulated with successive pitch shifts. Shifts in pitch up or down (moving from one delay time to another) begin with a default octave shift. The buffer length is variable. Once the patch was preset for recording, modulation algorithms and sound file loop (if desired), the remaining four parameters could be controlled "blind" with the HotHand ring.



Screen shot of the Max patch used (presentation mode) for the ICLI 2020 presentation

The HotHand uses a 3-axis gravity sensor, providing three data streams. From these we could reliably derive 2-axis orientation (pitch and roll), however the unreliability of the third orientation axis (yaw) made it difficult to implement higher-level solutions for recognizing specific and repeatable hand postures. While experimenting with such implementation we experienced too many cases of unexpected alignment of the gravity values of two or more different hand postures. We mapped pitch (wrist flex up/down) to the feedback level, and programmed roll (palm up/palm down) as a start/stop switch for the Tap tempo that determined delay length. At 100% feedback the Max patch would block signal input, so that gave us 3 parameters: delay time, feedback amount, and signal bypass. Through experimenting with a variety of gestures we were able to map specific hand positions that could be recognized from the combined data from the 3-axis accelerometer to Audio on/off. Even though the yaw was unstable, we found this work-around usable. Having access to a fourth parameter of Audio on/off significantly improved the musical expressivity in improvising with this patch. We also programmed the patch so that if the hand was held in the Audio off position for a specific (predetermined) length of time it would not be possible to trigger Audio on again from the HotHand. This allows the performer to control the end of the piece. For the ICLI demo performance the length of time chosen was set to 10 seconds.

It was important for me to highlight in the ICLI performance the aesthetic and technical issues that I am investigating with this research: the importance of presence and embodiment, the tensions inherent in blending acoustic and amplified/electronic signals, and the issues around performer agency and control of audio processing with a non-visual interface. Although I sampled my voice in real-time, I did not amplify my voice. Since the space was quite dry, I arranged with the technicians that they would raise the heavy damper curtains in front of the windows as I began the performance. That improved the acoustics for my un-amplified voice. I started the performance at one of the windows and used the sound of the motor raising the curtain as a sound source to improvise with acoustically.

View of the hall with the damper curtains raised.

Performing next to a window in the middle of the hall.

A number of participants at ICLI commented that the blend of my acoustic un-amplified voice with the electronic signals gave an intimacy to the expression, and that my movements in the space highlighted the acoustic properties of the space and the emotional/dramaturgical effects of performer position in relation to the audience. I got confirmation that the audience members understood that I was processing my acoustic vocal signal in real-time and that my gestures were mapped to audio processing functions that I had control of and could repeat. Many commented on the contrast between the mobility of my acoustic voice and the stationary stereo position of the processed signals. As this research progresses I will investigate possibilities for performer control of spatialization of the processed audio signal.

Going forward I am incorporating participant feedback and lessons learned from the presentation. I am currently testing a new version of the Max patch with Genki´s Wave ring. From initial tests it is clear that the Wave ring is more promising. It has a stable 3-axis orientation (yaw, pitch, roll) and three clickable buttons, including a dedicated Audio on/off switch and two programmable buttons that make it possible to control parameters that needed to be preset with the HotHand (record on/off, choice of algorithm modulation). Additionally the software that comes with the Wave ring provides for machine learning and custom adaptation of gestures. All this is welcome news since HotHand has discontinued its development of its wireless MIDI ring and is focusing now solely on their voltage control ring.

An interesting footnote: When I reviewed the video of the livestream from the ICLI 2020 conference, I discovered that not only did my presentation highlight the tensions between the differing needs of acoustic and electronic sound, but those tensions also manifested in the video documentation. Due to a technical error, the acoustic sound in the room was missing from the video recording and only the electronic parts can be heard. For my performance, the interplay between the acoustic and electronic components was integral to the aesthetic of the work, but I had neglected in my technical rider to think about my documentation needs, and I had not specified that I would need a room mic to document the acoustic sound in the room. The version presented in the recording thus deviates significantly from the actual performance presented at the ICLI conference. In dialogue with the conference organizers, it was decided to publish the recording anyway, as they felt the presentation as a whole contributes significant value to the field, and the recording of the performance is an integral part of it. It was a good reminder that the working practices that are assumed in opera and in electronic music circles are different, and those assumptions need to be taken into account if one wishes to combine the two.

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[7] Based on a Japanese folktale, *The Sailmaker's Wife* is the story of a man's kindness to an injured crane who returns to him in the form of a woman and becomes his wife. She brings him a magical secret gift, at the expense of her wellbeing. The gift is requested one time too often, and her secret is ultimately betrayed. When her true identity is revealed the Crane-wife flies away. Since this opera deals with magical transformation, it is an ideal candidate for the magic of audio processing, unusual controllers, and the integration of wearable sensors and controllers into the costumes and/or scenography.

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