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Abstract

This paper describes the various components of SuperPamplemousse, a customized sound system developed for the specific needs of the electroacoustic chamber group Ensemble Pamplemousse. The elements are as follows: microphone arrays for each instrument (flute, violin, cello, percussion, and piano), ranging from 2-6 microphones per instrument; processing capabilities in the form of a Pure Data patch; wearable speakers; and a composition to demonstrate the potentials of the system. This project seeks to resolve the compound problem of amplifying the dynamically diverse noise-based sounds of each instrument; and of spatially and aurally combining electronic sounds with acoustic sounds.

Keywords

Electroacoustic, chamber music, sound system, wearable speakers

Concept Overview

SuperPamplemousse consists of three distinct elements. These are: a microphone array for each instrument (flute, violin, cello, percussion, piano); wearable speakers; and the composition, which includes processing of each instrument. Each microphone array will consist of between 2 and 6 powered electret microphones, designed in such a manner as to maximize the noise capabilities of each instrument. Each ensemble member's microphone array will plug into his/her respective sound card and computer, and output to the wearable speakers. The speakers will be networked to allow each performer's sound to be sent to any other performer's speakers (see diagram). The wearable speakers will consist of an array of miniature 1-watt speakers, until the flat speaker technology which has recently emerged becomes available to consumers. The composition will be structured as to maximally demonstrate the potential of the mic arrays and localized speakers, and will using the processing capabilities of Pure Data.

Concept Diagram

Diagram 1a: mic arrays and output map, ideal (future)

Diagram 1b: mic arrays and output map, current

Rationale

Since the advent of electroacoustic chamber music- chamber music with electronics- composers and performers alike have struggled to find a balance between the acoustic and the electronic. Too often, this problem is ignored- the volume of the electronics remains at such a low level as to barely be heard, or the electronic sound emanates from speakers located in an entirely different acoustical space from the performers. To create a truly integrated electroacoustic performance, attention must be paid to the composite. This includes the merging of acoustic and electronic sound through amplification techniques and careful speaker placement, and choosing appropriate compositional material for this marriage.

The need for this sound system is multi-faceted. First, the ensemble is constantly compromising on matters of sound- deciding which sound will be amplified based on the equipment available rather than the desired musical effect. Secondly, the equipment currently used for amplification of these sounds can be damaging to the instruments and is limited in both mobility and placement. Finally, while high-end sound systems do exist for each individual instrument, a single microphone alone would cost upwards of $500, which is not a realistic possibility at this point in time. While the electret microphones are of somewhat lower quality, they are smaller capsules and therefore more mobile, and also easily replaceable if they are damaged. Since the primary use of the microphones is to amplify noise-based sounds- some of which are created by sharp movements- extremely expensive microphones are unnecessary and impractical.

Goals

1. To develop an inexpensive, high-quality, versatile sound system for the specific techniques and sounds used by Ensemble Pamplemousse.

2. To create a system of wearable speakers using the latest flat and flexible speaker technology, allowing the greatest freedom of motion and widest range of sound frequency and dynamic.

3. To compose a work highlighting the benefits of the SuperPamplemousse system.

Core Features and Functionality

Microphone Arrays

The flute receives microphone arrays for each of four flutes- C flute, alto, bass, and piccolo. The alto, bass, and C flute each receive two, and the piccolo receives one. For the larger flutes, the microphones are suspended inside the body of the instrument, held in place on one end by a magnet attached to another magnet tied to the headjoint; and at the other end by a coil of wire. One of the mics amplify the sounds of the keys and the internal sound palette, and the second microphone, at the end of the tube, amplifies pitch material. A possible expansion would be the addition of an external mic on the headjoint in traditional positioning, to further increase the range of breath sounds captured by the microphones. However, the majority of the breath sounds are captured by the internal mics. The flutist receives one volume pedal for each flute and a series of switches for on/off or processing control.

The violin receives two mics, each equipped with a gooseneck to allow for varied positioning. One microphone sits inside the F-hole, and the other is on the front of the bridge. Both mics clip onto the bridge with long alligator clips (hair clips). A possible expansion would be the addition of a contact mic embedded in the fingerboard. The violinist receives one volume pedal and one digital fader (SoftPot) for processing, located on the body of the instrument.

The cello receives two mics, each equipped with a gooseneck to allow for varied positioning. Like the violin, the microphones clip onto the bridge; one extends into the F-hole, and one is positioned in front of the bridge. Possible expansions include embedding two contact mics in the fingerboard. The cellist receives one volume pedal and one digital fader for processing, located on the body of the instrument.

The percussion receives seven mics; two each for two cymbals (each cymbal is miked at the bell and the rim), one inside the snare drum, one inside the floor tom, and one accessory mic. On the cymbals, the mics are also equipped with goosnecks; one mic on each cymbal is placed at the bell, and one each at the rim. The snare drum and floor tom mics are inside the drum to allow for maximum amplification possibilities, in particular of the snares. The accessory mic is used for any toys with a distinct but too-quiet sound, such as the doweled woodblock. The percussionist receives one pedal for overall volume, and a series of on/off switches for the mics.

The pianist receives six mics- two for the soundboard, two for the keys, one for the bench, and one for the pedals. One microphone for the soundboard is placed for amplifying the low end of the piano- either inside (for grand pianos) or behind (for uprights)- and one is placed to amplify the high end. The two microphones for the keys are similarly placed low and high. The bench mic picks up the body movement of the performer; and the pedals mic amplify the damper, soft, and sostenuto pedals. The pianist receives two volume pedals to control processing.

The degree of necessary versatility of processing control will be determined by each composition. The microphone arrays are intended to operate alone or with software manipulations, depending on the composers' desires.

The current iteration of the microphone arrays is less involved than the ideal described above. Due to a limited quantity of available sound cards, the total number of microphones has been reduced to six, for proof of concept. The flautist, violinist, cellist, and pianist each receive two, each pair mixed to a single input; and the percussionist receives two. For this composition, the piano will receive amplification for pedals and bench; the percussionist will have an amplified cymbal and snare drum; and the flautist will use only the alto flute. All of the microphones will enter into a single computer, and output through six distinct channels.

Wearable Speakers

The need for the wearable speakers lies in the inherent detachment between electronic and acoustic sounds. The acoustic sound is produced by the performer, and the electronic sound is produced either by the processing of the acoustic sound, or by an external synthesizer of the sound. Yet currently, however the sound is produced, it emanates from an arbitrary location some distance from the performers. The unification of electronic and acoustic sound into an integrated and intimate package is highly desirable and would be conducive to an improvement of the concert experience.

There are two current workable technologies for this project, neither of which is immediately available. The first is carbon nanotube thin film loudspeakers, developed recently (Feb 2009) by physicists at Tsinghua University and Beijing Normal University. These speakers are extremely thin films wired to electrodes, operating on a thermoacoustic reaction. Since sound is a pressure wave, it creates a parallel oscillation in temperature. If this condition is reversed- if a temperature oscillation is incited- then a pressure wave is formed, which is the sound emanating from the speakers. The speakers' dynamic range is affected by the thickness of the films; if multiple films are layered, the speakers are capable of producing louder sounds. These speakers are currently in the early stages of research, and are not available even for experimentation.[1]

The second potential technology was developed at the University of Warwick in the U.K., called Flat Flexible Loudspeakers (FFL). These are constructed of three thin layers of laminate, the two outer of which are conductive membranes and sandwich a third insulating layer. The electrical signal is applied to the laminate, creating an electric (rather than magnetic) field over the laminate, which then produces the necessary molecular vibrations for sound production.

[1] http://pubs.acs.org/doi/full/10.1021/nl802750z

These speakers are scheduled to become available for consumers by the end of 2009.[2]

Some alternative means of producing wearable speakers include using miniature high-powered speakers; using piezo speakers with lightweight resonators; plasma-ion speakers; piezoelectric polymer film speakers; and the delorean speakers used by the Princeton laptop orchestra (a sort of cheating wearable speaker, if hidden under the skirt). The disadvantages to these speakers are all fairly similar- they are not sturdy, falling apart or sustaining damage easily when moved; they produce sound of unacceptable quality; or they are lacking in bass range. The delorean speakers are of high quality and sturdy, but also extremely bulky, heavy, and not wearable.

For the proof of concept, arrays of six miniature dynamic single-watt speakers will be used on the dresses.

Further pursuit on this project will include grant applications and finding collaborators in physics and fashion.

Relevant Background

Miking

There is a great deal of history in the development of techniques for amplification of classical instruments. Countless manufacturers are constantly putting new pickups for string instruments on the market, each claiming to produce a more realistic (acoustic) sound than the last. Yet the field of electronics in contemporary music has received comparably little attention, due largely to the combined forces of insufficient funding and lack of knowledge on the subject.

One exception has been the work of Tod Machover at MIT, who created a host of "hyperinstruments" both for audience interactive works, and for musicians such as Yo-Yo Ma. These instruments employ sensors and processing techniques with the primary purpose of allowing any non-musician to create music. Those constructed around acoustic instruments produce almost exclusively synthesized sound, employing amplification techniques only as a method of porting the acoustic sound to the computer.[3]

Mark Dresser, a bassist currently teaching at UCSD, developed a customized system for amplification of normally inaudible sounds on the bass. This system consists of several mics embedded in the neck of the instrument, to pick up all the finger work as well as any extended noise techniques from that part of the instrument.

The Octopus is one recent example of a superflute. Constructed by Victor Adân, this is an 8-channel electret microphone system built with the specific purpose of spatially diffusing the sound of the flute. A bar attached to the outside of the flute holds the eight microphones in place.[4]

In fact, miking systems exist in abundance, at both extremes of the expense range. Extremely inexpensive pickups for string instruments can be implemented with limited success, poor sound quality, and high failure rate; or extremely expensive systems exist which produce very high quality but are also damaged quite easily, and are irreparable, in the immediate sense. This project is designed as a mid-level amplification system for musicians seeking to amplify a specific spectrum of sounds in a cost-effective manner without the sacrifice of sound quality.

Wearable Speakers

The concept of wearable speakers has been explored by composer/dancer team Curtis Bahn and Tomie Hahn in the conception of their character "Pikapika" and the associated Sensor Speaker Performance Interface (SSpeaPer). SSpeaPer is composed of a series of pressure and tilt sensors on Tomie's hands, small speakers on her arms, and a spherical array of stage speakers. Data from the sensors is converted to MIDI messages via a microcontroller mounted on one hip, and sent to the computer via a radio transmitter on her other hip. The sound is processed and sent back to her arms, giving the impression that she is producing the sounds, which are also spatially mapped to her movements.[5]

A successful example of using sound mapping to minimize the harshness of unidirectional electronic sound is the Delorean speaker system built by Dan Trueman and Perry Cook for the Princeton Laptop Orchestra. The concept of the system is to mimic the acoustical properties of instruments by constructing speaker arrays which would disperse the sound in a natural acoustic pattern. Trueman and Cook have done a great deal of research on sound mapping of acoustic instruments, revealing possibilities for exact digital reproduction of a physical environment. This information is not relevant to the development of the wearable speakers, since the physical space has a direct effect on the dispersion of sound and needs no manufacturing.

Technologically speaking, the idea of using thermoacoustics to create a loudspeaker dates back to the late 19th century, with the development of the thermophone by Sir William Henry Preece and Ferdinand Braun, and further theoretical research by H.D. Arnold and I.B. Crandall in the 1920s. No substantial product was ever developed, but the

2 http://www.warwickaudiotech.com/content.php?menu_id=3&page_id=23
3 http://www.newmusicbox.org/page.nmbx?id=06fp02
4 http://www.victoradan.net/blog/tag/la-espiral-quebrada/
5 http://www.arts.rpi.edu/crb/Activities/SSpeaPer/SSpeaPer.htm

research done by Arnold and Crandall demonstrated the possibility of using thermoacoustics to replicate sound, given the appropriate technology.

Compositional Elements

The initial inspiration for SuperPamplemousse lay in my long-standing dream to perform my instrument- the flute- in such a manner that a blind audience member would never guess the instrument. I realized this dream by putting my head inside the instrument and finding non-idiomatic sounds and textures hidden within the acoustic walls. This inspiration continued during my construction of SuperPamplemousse, and my initial composition reflects this. The first work for the ensemble was a loosely composed work demonstrating the sound potential of each instrument, unprocessed. Each performer was given a very limited set of sounds and asked to explore them to their fullest extent. I wanted to limit the "natural" possibilities of each musician in order to encourage her to explore the capabilities of the super instrument.

I built this system for two primary reasons: first, with the hopes of realizing my own compositional voice; second (and more importantly) as a tool for other composers.

Summary/Conclusion

Ultimately, an artist finds a way to produce the sound that is heard internally, with or without technology. For my purposes, I plan to employ technology because of my lifelong fascination with electroacoustic music, and because the sound I want requires amplification, processing, and consolidation and localization of sound sources.

More, later.

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