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Water Birds: Compositional Collaboration with Clarinets, Wireless Sensors, and RTcmix

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ABSTRACT

"Water Birds" is an interactive composition for Bb and bass clarinet, computer music and wireless sensor system by Mara Helmuth and Rebecca Danard. A wireless sensor network with infra-red sensors responds to the clarinetist's movements, and sends data into MaxMSP for signal processing control. The wireless sensor configuration was developed by Jung Hyun Jun, Talmai Oliveira, Amitabh Mishra, Ahmad Mostafa and Dharma Agrawal, and extended for this project in collaboration with Helmuth. MaxMSP Mxj Java objects were created to receive data from the programmed tmote sensors. Helmuth's score consists of four sound-generating ideas. Her Max patch and RTcmix scripts process the clarinet sound with spectral delays through the rtcmix~ plugin for Max5. Danard created a working score solidifying her decisions about materials played and order of events. Helmuth and Danard's interactive compositional process allowed to piece to evolve organically into a work commenting on the interaction of people, nature and technology.

1. INTRODUCTION

1.1. Interactivity

"Water Birds" for bass clarinet, Bb clarinet, computer and wireless sensor network is interactive, and the electronic part consists entirely of processed live clarinet performance, under the control of the performer through a wireless sensor network. Infra-red sensors react to movement by the clarinetist, and transmit data back to the computer for control of signal processing. The work was composed in 2010 by Mara Helmuth and Rebecca Danard, and has been performed at CCM on a Sonic Explorations concert, on the Performance and Time Arts Series at College Hill Town Hall, and will be performed at SEAMUS 2011 at the University of Miami. The compositional process involved discussion and choices made by both Helmuth and Danard.

1.2. Compositional Collaboration

Compositional collaboration has many benefits. A composer may leave decisions to a performer that a specialist on the instrument could make best, and which highlight the performer's special abilities. Instead of allowing a performer's contributions to a collaboration to be subsumed into a composer's composition unacknowledged, which often happens, we preferred to credit the decisions made by Danard as a composer's role. Often in computer music performance, the roles of composer, performer and audience become less rigidly defined.[4] Recorded material of a performer can work its way into a composition, and the composer may have to be actively engaged on the computer to realize a successful performance. In this case the compositional work included programming, designing the interactive system and creating a score of sound-generating ideas, contributed by Helmuth, as well as creating clarinet sounds, improvising on score fragments, choosing timings of events, creating a

working score, and assisting with the system design strategy, contributed by Danard.

1.3. Conception of the Collaboration

Rebecca Danard took a class from Mara Helmuth involving composer and performer collaborations in the spring of 2009. Danard had previously worked with composers on new music projects at Midwest Composers Symposiums, Bang on a Can and as president of the Ottawa New Music Creators. This course was one of her first experiences with electronic music, however, and she was hooked. She approached Helmuth about collaborating on a piece. Helmuth had extensively collaborated before both compositionally and with performers since 1995, and was interested in how Rebecca's clarinet playing would work with various signal processing algorithms. Having studied and performed with the Cincinnati Real Time Composers, Danard was an excellent improvisor and skilled in extended techniques; therefore an improvisational, interactive piece involving sensors was conceived. Danard's studies in biology, her interest in acoustic ecology and particularly her experience at Murray Schafer's "Wolf Project" would also inform her contributions to this work. Several Helmuth's previous works including "Abandoned Lake in Maine",[2] based on loon sounds, were motivated by her concern for wildlife and the environment.

1.4. Wireless Sensor Network Projects

Helmuth had also previously collaborated with Jun, Oliveira, Mostafa and Mishra, students of Dharma Agrawal, in several projects involving wireless sensor networks and music. [3] In several cases music was generated from dancer's movements,[5] and in an installation, sound was affected by audience movements. These projects made use of light, RSSI, pressure and accelerometer sensors. Helmuth's interest in computer music performance took new directions aurally and interactively with each sensor project. This project explored the use of a performer-controlled wireless sensor network.

2. THE SENSORS AND PROCESSING

2.1. Stage Layout

Four sensors are placed upon a small square table, one facing in each direction. Each Tmote sky sensor has an infra-red sensor attached, which senses the presence of the clarinetist when she stands in front of it, and transmits data to a basestation sensor. A microphone is in front of the table and picks up the clarinet sounds. Danard moves from offstage, around the table, and finally offstage again at the end of the piece. The basestation sensor which receives data from the four sensors on the table, is attached to Helmuth's computer which performs the signal processing at the side of the stage.

2.2. The Wireless Sensor Network

Five Tmote sky sensors are used. Four have infra-red sensors attached, and are programmed to send data to the fifth, the basestation which is USB-connected to the computer. Tinyos2.x light operating system was used to program the sensors and to forward the serial data into MaxMSP. Java objects in Max5 received the serial data and made it available to the Max patch. Four streams of data, one for each sensor, were used to control signal processing. The software was originally installed on OSX 10.4 and ran on 10.5. With a slight modification it is currently running on 10.6.

2.3. RTcmix Spectral Delays and Clarinet

The RTcmix music programming language8 is available as a Max plugin, rtcmix~[8], facilitating the use of its powerful collection of instruments with scripting capabilities. The RTcmix SPECTACLE() instrument is used to process the sound of the clarinet by altering its spectral timing characteristics. This techniques works most effectively on sound sources with a large range, so the decision was made to use the bass clarinet as well as the Bb clarinet. Helmuth created four different parameter settings for the delays were created, each paired with a sensor. This strategy allowed Danard to know what to expect from each sensor, and to choose sounds for each type of processing that would be most effective.

2.4. Max patch

Helmuth's patch performs signal processing on input audio signal in response to sensor data. There are four components to the patch, one for each sensor. In each component the sensor data controls whether audio is being recorded or not, and whether live sound or sound from a recorded buffer is being processed and heard. The patch was constructed to make the sensor activities transparent to the performer. Since there was a bit of unreliability in when sounds were triggered or whether they stay on, it is helpful for the performer to see what state each sensor/signal processing component is in. Three large lights display whether each sensor/signal processing component is recording, playing or playing from a buffer of recorded sound. The computer should be placed where the performer can see the screen, or the screen can be projected.

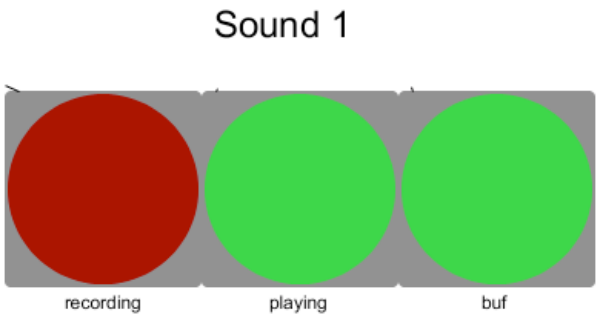

Figure 1 Three LED indicators for sound component 1, all in the off state. The first indicator highlights when recording is happening, the second when live sound is being processed, and the third when sound is played from a buffer recorded earlier.

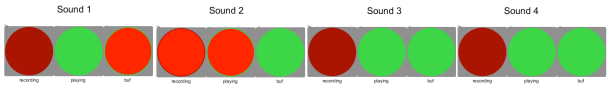

Figure 2 The display in this Max patch indicates that the recorded buffer is playing for sound component 1, after the performer left sensor 1, while sound component 2 is currently recording and playing, as sensor 2 is reacting to the performer's presence. Sensors 3 and 4 are inactive, neither playing nor recording.

3. COLLABORATIVE PROCESS

3.1. Initial Work

One of the first steps was a recording session to provide Helmuth with material to work with in creating the processing strategy. Extended techniques and improvisations were part of the recording session, and were a great resource in creating the Max patch and RTcmix scripts. None of this recorded material was used in performing the piece.

From an array of possible sensors the composers decided to focus on the infra-red, and Helmuth chose the spectral delay processing technique, which worked well with the clarinet sounds.

3.2. Processing Strategy

After Helmuth created a spectral delay patch, Danard began to experiment with material. Hearing the sounds of the processing greatly influenced how we decided to use the sensors. Because the processing had long-lasting and complex repercussions for every sound played, most of Danard's first improvisations quickly turned to mud. She discovered that it worked best to play a very simple motive to set up a sound world, and then turn off the processing in order to improvise. We found it best to allow the performer to set each of the four sensor/processing components to one of four states: recording and processing, playing with processing, only playing the recorded buffer with processing, and not playing. Helmuth programmed this functionality and fine-tuned the timings and spectral delay parameters of the RTcmix instrument to avoid overloading the CPU.

3.3. Stage Layout

Originally we had four microphones, one with each sensor, on different parts of the stage. This setup was cumbersome because the microphone cables could obstruct the performer's movements and increase the likelihood of moving the sensors, which caused them to respond unpredictably. Recently we found the solution described above, using one small table with the four sensors facing outward, and one microphone. This reduced

accidental triggerings and gave Danard more space to move during performance.

4. THE SCORE

As the collaborative process evolved, the first decisions were regarding processing sounds and creating the sonic and physical environment of the piece. The score was one of the last parts of the piece to be created. Helmuth felt that a score of sound-generating ideas would be less rigid and more likely to encourage intense listening than a fully notated piece. Also, because Danard's improvisational skills are excellent, she could be trusted to create an interesting listening experience. The sound-generating ideas include notated fragments that can be transformed by the performer. Figure 3 below shows one of the sound-generating ideas: a long tone going into a half-step trill and then fluttertonguing in the middle of the tone only.

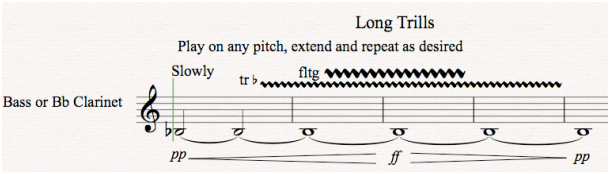

Figure 3 "Long Trills" sound-generating idea

On the Nondependence of Mind

Water birds
going and coming
their traces disappear
but they never
forget their path.

Figure 4 Poem by Dogen Zenji

Helmuth also selected the above poem[6] by Zen Master Dogen Zenji to be one of the sound-generating ideas. Experience with Zen meditation, Tai Chi Chuan, collaborations with other performer-composers and Pauline Oliveros's Deep Listening®[7] retreats have influenced Helmuth to rely on the intuition of the performer to create a successful performance. The score also draws its inspiration from nature, in the poem's imagery, as well as the "like a butterfly" direction in one of the sound-generating ideas, and the timbral aspect of the sounds. The importance of the natural environment is one of the themes of the piece. As the Deepwater Horizon Gulf of Mexico oil spill of September 2010 increased our awareness of the presence and extreme vulnerability of water birds, the poem became particularly meaningful. Instead of the original wonder felt at the birds' intelligence and skill in navigating their environment, the poem now seems to hint at "traces" that may soon disappear completely, and it makes one question whether we still live in a world where "they never forget their path."

5. INTERPRETATION

5.1. A Structure from the Score

For Danard the poem by Dogen was an inspiration on a macro-level, whereas the notated musical fragments were a stimulation on the micro-level. The idea of "Water Birds" brings to mind a whole soundscape – the call of a loon, the cry of the seagull, the flapping of a duck's wings, the splash of a kingfisher, the ocean's waves, the rushing river. These are the sounds that Danard wanted to evoke with the clarinet. The "going and coming" is how she interacts with the sensors and the sounds. With the microphone and the sensors in a central location, she move toward them or away from them to activate or deactivate the infrared. As sensors are turned on and off the sounds that she created with them will appear and disappear. Thus "going and coming" refers not only to her movement on stage, but also to the sounds of the piece. "Their traces disappear but they never forget their path" is a metaphor for how this piece works. Because it is improvised, each performance is unique and ephemeral; its traces disappear as soon as they are created. On the other hand, the "path" of this piece is highly structured and very consistent, both literally and figuratively. Each iteration of the piece has the same form; the same sounds are created the same sounds in the same order using the same sensors. A fixed path within the

performance space is traversed. Improvisation occurs within this structure.

5.2. Initial Decisions

To work effectively with the system there are several important decisions Danard made in advance of and during the performances. Her first step was to create a repertoire of sounds to draw on. At first it might appear that the musical fragments in the score are not much to form the basis of a piece. On the other hand, since there are two instruments (clarinet and bass clarinet), three fragments, and four different ways of processing, there are a total of 24 different sound possibilities just using the most literal interpretation of the music. After much experimentation, Danard developed eight sounds to use in this piece inspired by the idea of water birds and/or by the melodic fragments in the score. Although they are not conventionally notated these eight sounds are distinct from one another and relatively consistent from performance to performance. In addition to musical characteristics such as pitch, rhythm and timbre, each sounds is associated with one of the four sensors. Having created these eight sounds, the next step was to arrange their sequence and simultaneity. These choices were mostly made to give a musical shape to the piece, but there were also practical because of the limitations of the system. For example it is not possible to have two sounds produced by the same sensor playing simultaneously. It was necessary to minimize the need to switch instruments and the eliminate movements that were likely to accidentally trigger sensors. There are also sections when Danard deliberately moves away from the sensors and improvises over the sounds she has created and even a moment when she turns off all the sounds and allow the silence to return. The complete outline of the piece is shown in Figure 5. Each time a sound is initiated or terminated, the performer needs to trigger the appropriate sensor. Danard used this outline to plan and memorize her movements in the performance space.

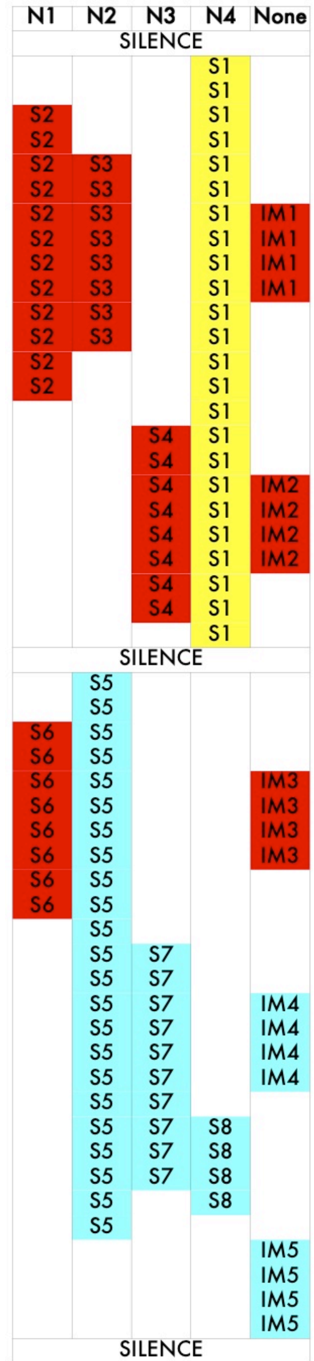

Figure 5 Outline of the form of Danard's interpretation of "Water Birds". Time moves from top to bottom. N1-4 are the seNsors. S1-8 are the Sounds. IM1-5 are unprocessed IMprovisations. Red highlighting is clarinet; cyan highlighting is bass clarinet; yellow highlighting is key clicks.

5.3. Sonic Realization

The harmonic basis for Danard's version of "Water Birds" are the four long tones (C, Bb, Ab, G) which make up the third sound generating

idea. To keep this harmony pure, she rarely plays any other notes while the processing is on. There is more freedom during the improvised sections when the processing is off, but the music still centre around these pitch classes. Changing registers, dynamics and articulations as well as using the different processing associated with each sensor yields a rich variety of sounds, while limiting the pitch content gives the piece unity.

Because the piece is all about movement, the piece begins the moment the clarinetist enters the performance space. With the sensors in the centre of the stage, however, the sound processing cannot begin until she reach them. Starting the piece with Sound 1, key clicks on the bass clarinet, sparse at first and then more densely textured, make a smooth transition from acoustic to processed sound. On the bass clarinet, it is possible to get a range of sounds with key noise; some is purely percussive, but some can have clear pitch content. In keeping with the harmonic plan, Danard uses single clicks on C and G and a repeated click on Ab before moving to more percussive sounds. The processed key sounds create the effect of beating wings, rain and ocean swells. This sound forms the backdrop for the entire first part of the piece. Having begun with very subtly, Sound 2 introduces the clarinet sound gradually with a single pitch – the low G on the clarinet. Some flutter tonguing and microtonal trills, inspired by Part 4 of the score, add to the texture and blend into the ocean sounds. Sound 3 introduces the full harmonic content of the piece for the first time by means of long tones in the over the entire range of the clarinet. In this section the challenge is to get as many different pitches into the buffer, without seeming to rush the long notes. Once all of the notes are in play, the sound and the processing becomes much more interesting. This is because in addition to consonant intervals – thirds, sixths, fourths and fifths – there are possibilities for second and sevenths. In fact the only interval not in the set is the tritone. Depending on the order of the pitches and the time between them Sound 3 creates a shifting cloud of consonance and dissonance. Sounds 1,2, and 3 create the environment for the first improvised section.

Sound 4 was developed very early in the experimentation process and directly inspired by the "butterfly" section of the score. It is also the only sound which deviates from the core pitch classes. For this reason only Sound 1, which is essentially pitch-less, overlaps with Sound 4. What makes this sound special is the interaction of the processing with the acoustic properties of the clarinet. The processing associated with Sensor 3 brings out the harmonic overtones of the sound that is playing. Unlike most wind instruments, the clarinet over-blows at the 12^{th} rather than the octave. This means that in the clarinet sound the odd numbered partials are much more prominent than the even partials. When short staccato notes played in the low register of the clarinet are processed by Sensor 3, the 3^{rd} and 5^{th} harmonics begin to pop out of the texture. Danard begins Sound 4 on C4, which produces the overtones G5 and E6 – a major triad. Then she adds G4 which produces the overtones D5 and B6. These pitch classes (C, E, G, B, D) form the set (01358). The core pitches (C, G, Ab, Bb) form the set (0135). Although the pitch classes are different, the sets they make up are strikingly similar. It is important to note that pitches for Sound 4 were arrived at entirely intuitively and aurally, not by analysis of the sets involved.

The second half of the piece begins from silence and is dominated by the bass clarinet. As in the first section, sound are created, layered and improvised around. To conclude the piece, Danard turns off all the sounds. As the buffers finish playing, Danard exits the stage which decreases the volume and intensity of her playing to fade out with the processing.

5.4. Indeterminacy in Performance

Despite this careful planning there are still many decisions that are made during the performance. The first 30 seconds after turning on the sensor are the most important because this is the material that is recorded and stored in the buffer. Anything that is not stored in the buffer will stop playing after the performer moves away from the sensor. Another consideration is the length of each segment. This is partly a practical consideration determined by how long it takes the

performer to move around the stage. It is also an artistic consideration, since some segments have inherently more musical interest than others, and therefore deserve more time in performance. Danard balances the form of each performance so that one section flows naturally into the next. Finally, despite our best efforts, sometimes things go wrong. An inadvertent movement can accidentally turn a sensor on or off, a glitch in the data can make a buffer not record, or sometimes sounds are produced unintentionally. These are the risks of any live and interactive performance. The key is to know the technical and musical characteristics of the system well enough to make the "mistake" sound deliberate and get back on the right track as seamlessly as possible.

6. CONCLUSION

The indeterminate nature of the score raises the question of how it would transfer to another performer. Danard says, "I think of what Mara has created in 'Water Birds' as a beautiful playground. What is special about the piece is that, rather than telling me what I can and can't do, she has allowed me to create my own game. At first I explored, discovering all the features and attractions, but over the course of the project I discovered which ones were the most rewarding for me. Like a made up children's game, there are definitely rules, but I get to create them and change them to suit myself. With a video recording and some verbal explanation, I could teach another clarinetist the rules of my game and how to play my piece, but this is only a limited use of the 'Water Bird' sound world. What I have chosen to do will never be as natural or comfortable for another performer as it is for me or as what they could come up with on their own. In working out my interpretation of the score, I had to engage much more intensely and creatively with the music, than I would have if Mara had given me detailed instructions about how to play the piece. Because of this investment of time and energy, the piece is much more interesting, personal and rewarding to play. I hope that future performers will not follow my disappearing traces, but follow their own path into 'Water Birds.'"

7. ACKNOWLEDGEMENTS

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