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Robert van Heumen - The new Baroque organ as a hybrid electro-acoustic instrument

[§294] My name is Robert van Heumen. I am a composer, improvisor and laptop-instrumentalist. I use the laptop as a sound-generating device controlled in an instrumental and tactile way, connecting action to sound like an acoustic instrument. Live sampling is my main tool.

Introduction

[§295] I started working in the field of electro-acoustic music around the year 2000. My first entry in this field was at the Studio for Electro-Instrumental Music (STEIM) in Amsterdam, where after a year of odd jobs and volunteer work I was offered a position as a project advisor. At STEIM I assisted in a wide variety of projects by artists developing their electro-acoustic instruments. It was also at STEIM that I developed my own laptop-instrument and built my experience as an improvisor using this instrument. My experience with organs is of a more recent date: in 2012 I contacted Orgelpark with a plan for two compositions: *First Law of Kipple*, a composition for 4-channel soundtrack and MIDI-controlled Sauer organ and *Tubes in Chains*, a composition for various amplified and distorted organs, flute with electronics and laptop-instrument. The latter was commissioned by Orgelpark and performed by my band Shackle (with Anne La Berge) and Dominik Blum on November 3 2013 in a concert also featuring *First Law of Kipple* (*FLoK*) and two pieces by David Dramm. To explain the use of the organs in both compositions, I would like to go into details a bit. *FLoK* is a piece played back by the computer using Steinberg's Nuendo multi-track audio software, where audio sent to the 4 speakers and MIDI sent to the Sauer organ's digital interface is synchronized. The work is fully automated: once started, no human interference is necessary. Registers are changed during the piece by sending the appropriate MIDI control messages.

[§296] When I was working on this piece in 2012, the MIDI specifications were not fully documented yet, so I needed to research the response of the interface to MIDI messages sent from the computer. This gave me valuable insight in the MIDI-implementation of the interface and also made me aware of its flaws.

[§297] As opposed to the quite simple setup for *FLoK*, the configuration for Tubes was much more complex. It involved amplification and live sampling of the Sauer and Chest organs, using distortion pedals on both organs, adding the acoustic Molzer and Verschueren organs, live sampling of the flute, using a partly notated score with visual cues and three performers. On top of this dealing with the unusual acoustic space and the diametrically opposed characters of the very direct and dry electronic sound of Shackle and the slow and reverberant acoustic organs.

[§298] Relevant to this essay is mainly the amplification of the organs: the Sauer feed came from two dynamic microphones already present in the organ, usually sending a signal to the speakers in the original console below it to provide the organ player with more direct aural feedback. Theoretically a far from ideal situation, using dynamic microphones and only two of them, as some pipes would sound much louder than others and the sound quality would not be great. But for *Tubes* this turned out to be sufficient. The subtle amplification helped the acoustic organ sound to blend with the electronic sound from the speakers, and it gave me a quite direct signal for live sampling that matched the original sound of the organ. The Chest organ was amplified using two Neumann microphones inside the instrument. This also provided a direct signal for live sampling and helped the instrument to be more present in the electro-acoustic sound field. The "extra-musical" sounds of the mechanism and the blower of both organs added texture and more character to the piece and created a vibrant buzz in the speakers: a sound bed that strengthened the blend of the acoustic and electronic worlds. The original plan for *Tubes* also included a section where the organ player through the digital Sauer console would trigger and control flute samples on the laptop-instrument and simultaneously I would trigger notes on the Sauer organ with the joystick that is part of my laptop-instrument. After numerous experiments I decided to postpone the idea for a next piece, mainly due to a lack of musical necessity. I had not found a satisfactory method to map the collection of continuous controllers that constitute a joystick to a series of on/off events to trigger organ notes. The essential difference between continuous and discrete seems to be the issue here, and I have not solved that yet. A secondary reason to drop the idea was the limitation of the MIDI implementation on the console: the organ would stop responding to MIDI if too much information was being sent. This is an issue that definitely should be addressed designing the new organ.

General remarks

[§299] This essay constitutes my ideas concerning the plans to build a Baroque organ incorporating 21st century technology. In my opinion these plans are a perfect excuse to build a hybrid electro-acoustic organ, incorporating acoustic and electronic sounds, merging the best of both worlds. But first of all the most important aspect that should govern all decisions: LIMITATION. In computer-based electronic music, if you do not limit your possibilities, you get nowhere. You play around with programs, with plugins, with effects, with toys, with hardware, but you only scratch the surface, you never go deeper. If you limit yourself, if you force yourself to work with what you have, then you have to go deeper. So: make choices, limit the possibilities in the acoustic design but more importantly in the electronic design. Most composers will not have much time anyways to work with the instrument, so they do not have the time to sculpt the instrument exactly as they like. Provide presets, but also provide the possibility to make one's own presets. Develop an instrument with character. An instrument that can not do everything, but that can do a limited number of things really well. Do not be afraid that the instrument will only fit a small number of composers and performers: everyone will find a way to make beautiful music with it. Limitation sparks creativity. The remainder of this essay consists of a collection of suggestions for the design of this hybrid electroacoustic organ. In itself these suggestions are very personal, I believe that there should be multiple discussions about these aspects, these limitations. Every outcome is acceptable to me, as long as clear decisions are made. One last remark: I do not know much about organ technology, so some aspects that I would like to see in this new organ might not be very feasible with respect to the mechanics of the organ.

Microphones

[§300] I understand the urge to have a very flexible microphone placement system, but limitation is important. Thinking about my preparation time for the pieces I created for Orgelpark, I am actually glad I did not (have to) go through the process of placing different microphones in different positions in the Sauer organ and figuring out what sounded best. This could have easily consumed all the time I had working with the organ, let alone the practical issue of working alone and having to walk up and down all the time repositioning the microphones. I actually worked a bit on amplifying the Molzer organ, placing microphones, but as soon as I realized that it would take a long time finding the right spots for a decent signal to sample I stopped and decided to not amplify the instrument at all. This may sound lame to you, me being just lazy not wanting to go through the trouble. But for me this is being practical. As much as I like technology, I rather spend my time making music.

[§301] So what then? I would opt for a number of fixed microphones and a smaller number of flexible ones, a combination of contact microphones on the mechanism and condenser and dynamic microphones placed in strategic places with a couple of patch-bays to limit cables running through the organ. This of course needs experimentation and is highly dependent on the space around the pipes. The goal should not be to cover all pipes in an equal way, that would be impossible (or would need one microphone for each pipe), so choices would have to be made, again. Some of the pipes and parts of the mechanism could be treated as special and have a dedicated microphone (these could be called “effect sounds”). Of course this would have to be documented, so composers can take advantage of those effect sounds. All the microphones signals would have to be accessible on the floor through a patch-bay. When working alone in the hall it is very useful to have access to the audio signals right next to the digital console. To further limit the multitude of options, some microphones with similar functionality could be combined within the patch-bays. For example a couple of “overhead” microphones or a couple of mechanism contact microphones combined into one stereo signal. These combinations can be seen as an example of the presets I talked about earlier. The best approach in my opinion would be to plan three phases in the process: building the acoustic organ while reserving space for microphones, then experimenting with the placement and in the last phase mounting the microphones.

Speakers

[§302] There are multiple reasons why speakers should be included with the organ. First of all there is of course the amplification of the microphones inside the organ. Then there is the playback of electronically generated sound from a sound engine inside the organ (I would call this “internal sound”; more on this in the next section) and playback of sound from another source (“external sound”; for example sound from a computer to play back in one of the speakers inside the organ to resonate with a specific pipe). To achieve a good blend between the acoustic and electronic sound generated by the organ it is essential that there are speakers inside or very close to the organ. Having both would be ideal. Just like with microphones I think choices have to be made regarding placement of the speakers. Obvious positions are of course immediately left and right of the organ. More interesting options would be inside the organ and opposite of the organ on the other balcony to incorporate the room into the sound of the organ. Speakers inside the organ can be divided in “amplification” speakers to play internal or external sound to make it merge well with the acoustic sound of the pipes and “effect” speakers that are placed for example right above certain bigger pipes to create resonance of internal and external sound within the pipe. Whether this will be effective as a composition tool has to be researched. Last but not least, there should be a subwoofer inside the organ, for resonance and to playback internal and external sound in the lower frequency domain. Again I would opt to first build the acoustic organ and then experiment with speaker placement before mounting them. A couple of patch-bays would be necessary to route microphones and internal and external sound inputs to various speakers, both internal as specified above as external, for example PA speakers on the floor. The patch-bays would ideally be placed both right next to the organ and below on the floor.

Sound engine

[§303] Orgelpark’s Sauer organ is MIDI-controllable and has two microphones inside that can be used for amplification and live sampling.

Adding multiple microphones and speakers to the new MIDI-controllable Baroque organ is already very exciting. Going one step further by adding a sound engine inside the instrument and thus creating a true hybrid electro-acoustic organ would be mind-blowing. Imagine a perfect blend of great acoustic pipes and versatile electronic sound, being able to live-sample an acoustic register and play that back instantly with just a little change in pitch or timbre, merging that with other acoustic registers and strangely familiar organ-like sounds generated by the physical modeling module, then adding gesturally controlled extremely pitched-up and -down sampled material from the mechanism of the organ, grounded by an extremely low-pitched throbbing sine tone. Wow, that would definitely be amazing. Of course any electro-acoustic composer could bring his own tools and create electronic sounds in combination with the acoustic organ. But we can offer them new possibilities, open up new sound worlds, have composers and musicians think outside the box, create music that would be unthinkable without this instrument. And: if we arebuilding an organ anyway, consulting experts in various fields and limiting ourselves by making decisions on what to include and what to omit, why not add the electronic aspect? We have the knowledge and we have the means. Again, we could never satisfy every composer wanting to work with the organ, but compare it to presets in music software or on hardware synthesizers: it gives the less-experienced composer a selected choice of sounds to start with but at the same time allows the experienced composer to create his own sounds. We would also attract composers and players just because of the very special character of this instrument – people who might otherwise not think of writing for or playing a church organ. Widen the horizon.

[§304] The sound engine would ideally consist of three modules: virtual analog synthesis, sampling, and physical modeling synthesis. All three would reside on a computer inside de organ, to be configured from interfaces right next to the organ as well as next to the digital console on the floor. Both interfaces could be a computer or an iPad, depending on the complexity of the software interface, connected by ethernet using screensharing to connect. The computers would be running Mac OS X and the one inside the organ would be connected to a high quality audio interface. The electronic sounds would be triggered from the manuals of the organ, to be selected in a similar vein as registers of the acoustic organ. A manual could be connected to one specific pitched sound but there should also be the possibility for every key to trigger a different sample. Combinations should also be allowed: for example a certain region of the manual playing different pitches of a sine-tone and another region triggering individual environmental samples.

Analog synthesis

[§305] For the analog synthesis module one could think of a hardware analog synth, but since we would like to have control of the processes in two places it would be more practical to have a virtual analog synth running on the computer inside the organ. This could be dedicated software or a custom program built in SuperCollider or any other sound programming environment. It would consist of the traditional analog synthesis components like oscillators, filters, envelopes, amplifiers and LFOs. Although you can create any complex sound as a combination of these components, I would imagine using this analog module for relatively basic sound material that blends very well especially with the pipes of the organ.

Sampling

The sampling module could also be either a dedicated commercial package or a custom program built in a programming environment like SuperCollider. The latter would give us more flexibility to customize the module, but would potentially be more costly to develop. Although customizing a commercial program could also be quite time-consuming and thus expensive. The choice would be mostly between the flexibility of a custom program and the support structure that comes with commercial software.

[§306] The sampling module can be divided in two parts: sample playback and live sampling. The sample playback part would have a library of samples to choose from and the option to include one's own samples and to save live sampled acoustic sound from the organ. The library could be allowed to grow as more people use it. Initially it could have a bank of samples from the organ itself, for example to be able to play the acoustic pipe and its electronic counterpart simultaneously where the latter could be processed. And like it was mentioned on the Orgelpark blog, it would allow for a comparison of both sounds, which could be an interesting study in itself.

[§307] We could include other samples that potentially would be of interest to many composers; one could think of banks of environmental sounds, factory sounds, mechanical sounds or speech. Of course banks of recordings of other organs would be interesting; this would again open up the possibility of research into the question whether acoustic pipes might become irrelevant as recording and playback technology progresses into the area where recorded and original sound becomes indistinguishable. Personally though I believe a recording could never replace the presence of a physically resonating object in a space; on the contrary I would be very interested in playing all kinds of samples through speakers projecting into the bigger pipes and hearing their resonance. To build up a sample library we could also consider publishing a call to sound artists to send in proposals.
[§308] The live sampling part of the sampling module can be seen as a dynamic sample bank. We could have a "dynamic register" (as discussed further on) consisting of "recording keys" that record from a specified microphone into a specific position in the sample bank and "playback keys" that playback recordings in that sample bank.

Physical modeling
[§309] The third module: physical modeling. This is a technique where sound is not built through additive or subtractive synthesis using sine waves, noise and filters, nor is the sound derived from processing samples. From Wikipedia:

> Physical modeling synthesis refers to methods in which the waveform of the sound to be generated is computed by using a mathematical model, being a set of equations and algorithms to simulate a physical source of sound, usually a musical instrument. Such a model consists of (possibly simplified) laws of physics that govern the sound production, and will typically have several parameters, some of which are constants that describe the physical materials and dimensions of the instrument, while others are time-dependent functions that describe the player's interaction with it, such as plucking a string, or covering tone holes.

My only experience with this synthesis technique is using Logic's Sculpture plugin in *First Law of Kipple* (as described in the introduction), but I see a great deal of potential in combining this with the acoustic organ.

MIDI support
[§310] Orgelpark is already building a lot of experience with MIDI-controllable organs through the presence of the Sauer organ. We should use this knowledge and consult composers who have worked with the Sauer for the MIDI implementation in the new organ. Since it seems already decided that the new Baroque organ will be MIDI-controllable I will not discuss the pros and cons but go into the details of the implementation immediately.
[§311] First of all there should be some thought about how to use MIDI channels. The MIDI communication protocol distinguishes 16 independent channels. Originally these channels were thought of representing different instruments; in MIDI studios the various digital instruments could be separated by controlling them on different channels. Just like with the Sauer organ, the digital console for the new organ should distinguish the three manuals and the pedals by having them send the MIDI on separate channels. Aside from musical information like triggering notes or changing the position of the swell pedal, MIDI can also transmit configuration information, like the selection of registers or controlling octave switches. On the Sauer organ this proved very effective: when controlling the Sauer from a computer one can engage registers during a piece without physically touching the register switches on the digital console.
[§312] Taking this a step further, MIDI can also be used to transmit meta-control data: selecting a registration preset on the digital console and even go into the console menu and change global settings. As powerful as this is, it is also dangerous and has to be thought through. There have been examples where the Sauer organ stopped responding to MIDI while pipes were sounding, and that of course is an undesirable effect. While this can never be completely avoided, we should make sure the MIDI implementation distinguishes clearly between the various types of data.
[§313] I would recommend transmitting configuration data and meta-control data on separate channels. It would be best to use channels 14 and 15 for this. Generally when adding tracks to MIDI software each track will

automatically be assigned a new MIDI channel to transmit from, starting from MIDI channel 1; so it is ill-adviced to use any of the lower numbered channels for non-musical data. Some MIDI software uses MIDI channel 16 for configuration data, so for that reason I would not use that channel on the new organ either. As a next step in MIDI control for organs, I would like to see MIDI continuous control of the valves for each pipe. This could help bridge the gap between the discrete character of the organ, where there is no way to add more expression to the sound of a pipe once triggered, and the continuous character of external controllers. Having continuous control over the opening of the valves could create an extra layer of expressiveness. Another aspect in MIDI control could be the speed of the wind motor. I have used the "motor ab" switch on the Sauer organ in the *Tubes* composition (as described in the introduction) to have tones glissandi down; it would be great to have more control on this aspect. Even better would be the possibility to control this independently for multiple groups of registers.
[§314] A note on register and assignment switches: on the Sauer digital console these can be controlled by sending their appropriate MIDI note number: a velocity of value 127 would switch that particular switch on if it was off and off if it was on. Meaning that if the organ player would switch them manually, there is no way the computer knows the correct state (on or off). It would be much more useful being able to set those switches to on and off by sending velocity 127 and 0 respectively.
[§315] Last but not least: a solution has to be found for the fact that too much MIDI information sent to the Sauer digital console makes it crash. It is disturbing that even a restart of the digital console doesn't always seem to reset the instrument.

Interface
[§316] The new organ as discussed above has the following components:

- A collection of acoustic pipes, including the electronics that controls the opening of the valves
- A sound engine computer
- Speakers and microphones inside and around the organ, including patch-bays
- An analog keyboard console (including register/assignment knobs) and digital screen interface on the balcony
- A digital keyboard console (including register/assignment knobs) and digital screen interface on the floor

[§317] To discuss the interface of this hybrid organ, I would like to introduce some terminology. The organ will consist of various traditional Baroque registers which are divided into traditional assignment groups. Let us call those registers "traditional" and their pipes "acoustic". The acoustic pipes have as their counterpart the electronic sounds from the sound engine; let us call those sounds "electronic pipes". The counterpart of traditional registers I will call "dynamic" registers: freely assignable registers consisting of combinations of acoustic and electronic pipes. With dynamic registers every manual can be a combination of every thinkable combination of electronic and acoustic pipes.
[§318] Let us now discuss screen-based control versus dedicated knobs. We have a great number of configuration and musical parameters to control: building electronic pipes in the sound engine, configuring dynamic registers, assigning traditional and dynamic registers to manuals, specifying microphone and speaker routings. Some of these actions should have dedicated hardware interface elements, others can be configured using a screen either using a mouse/computer keyboard combination or a touch screen. As a rule of thumb I would advise to have physical knobs for direct musical actions like selecting and assigning registers, and use a screen for more preparation-type actions like building dynamic registers. Next to register and assignment switches for the traditional registers, I would opt for a range of physical dynamic register switches. I would say that we could have 3 assignment groups of 5 registers each. Every one of those registers can combine acoustic and electronic pipes. These registers can be seen as presets to be programmed and assigned by the composer beforehand. Just like the swell and roll pedals, we could consider adding an array of pedals to control parameters of the electronic pipes. Some of these could be setup to control specific parameters like pitch or volume, others could be left open to assign by the composer.

Tuning

[§319] I do not have a specific preference for a tuning system. What would be an interesting idea though is to add pipes or objects that can be blown but have no determined pitch. These can be treated as “acoustic effect sounds”, analogous to non-pitched electronic material like environmental sounds.

Conclusion

[§320] I would strongly recommend taking this opportunity to build a hybrid electro-acoustic Baroque organ consisting of acoustic and electronic pipes and traditional and dynamic registers. With respect to the electronic part of the organ I would advise to build it in three phases: first decide on the type and rough number of electronic components (speakers, microphones, sound engine, interface elements) and build the acoustic organ keeping in mind these components. Secondly experiment with various electronic components: microphone and speaker type and placement, various electronic sounds; then decide on their specifics and build this. Finally we can make an inventory of all the control parameters we need and design and build the digital console incorporating all the details.

The new Baroque organ as a hybrid electro-acoustic instrument [abstract]

The plan to build a Baroque organ incorporating 21st century technology is a perfect excuse to build a hybrid electro-acoustic organ, incorporating acoustic and electronic sounds, merging the best of both worlds. The most important condition would be *limitation*: if we don’t limit our possibilities, we get nowhere.

I would opt to first build the acoustic organ and then experiment with microphone and speaker placement. Patchbays would ideally be placed both right next to the organ and below on the floor. Going one step further by adding a sound engine inside the instrument and thus creating a true hybrid electro-acoustic organ would give the less-experienced composer a selected choice of sounds to start with, and would allow the experienced composer to create his own sounds. The sound engine would ideally consist of three modules: (virtual) analog synthesis, sampling, and physical modeling synthesis. The interface to the hybrid organ should contain both register and other dedicated knobs, but a digital screen interface as well. As a rule of thumb I would advise to have physical elements for direct musical actions like selecting and assigning registers, and use a screen for more preparation-type actions like building dynamic registers. My suggestion would be to first decide on the type and rough number of electronic components (speakers, microphones, sound engine, interface elements), then build the acoustic organ keeping in mind these components. Using the analog console of the organ experiments with these electronic components can be done (mic and speaker type and placement, various electronic sounds). That would be phase 2. Phase 3 would be building the system.

Robert van Heumen

Robert van Heumen is a composer and improvising musician using an extended laptop-instrument to perform highly immersive and hyper-dynamic electro-acoustic music. Van Heumen is continously researching new strategies for live sampling and looking for the perfect balance between free improvisation and structured music. The laptop is used in an instrumental, tactile way, connecting action to sound like any acoustic instrument. Van Heumen is performing regularly with his band Shackle and various other constellations. Van Heumen teaches music programming language SuperCollider at the Conservatory of Amsterdam and collaborates with Anne La Berge in teaching Converging Objects workshops on live electronics and structured improvisation at universities and other educational organizations, both in the Netherlands and internationally. Van Heumen worked for 10 years at the Studio for Electo-Instrumental Music (STEIM) in Amsterdam as project manager, curator of the Local Stop concert series and member of the artistic committee. In a previous life he was a trumpet player, mathematician and software programmer.