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New learning opportunities using virtual organ in music studies

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Nowadays learning to play an instrument is possible in a virtual environment too. In this article we will be taking a look at what is a 'virtual organ' and exploring some possibilities on how it can be applied in music studies.

INTRODUCTION

Virtual organ is a kind of pipe organ that does not have pipes. The pipes are replaced by speakers that reproduce the sound corresponding to each pipe. In the past, these were "electric organ" that also imitated the sound of a pipe, but the new generation of virtual organ differs from previous electric organ. Virtual organ operates in an online environment using recorded CD-level audio files producing the pipe sound. A virtual organ can also store audio file banks of several different organ at the same time and change the type of organ to be played at the touch of a button. Because virtual organ work in an online environment, they can also be updated. The user can purchase new organ types as well as edit and adjust the settings remotely. At the heart of the organ is a powerful computer with a large memory capacity (1TB SSD, 64GB RAM) to which the audio files are downloaded either from a memory stick or via the network. The actual playing event does not require a network connection. The computer opens the audio files containing the sound of the pipes from its own memory depending on how the keys are pressed. The aim is to build the virtual organ's console, its keyboards, register switches, music stand, pedal keyboard and organ bench to be practically the same and feel the same as in real pipe organ.

Picture 1a (left): Pipe organ of Helsinki Cathedral, Finland
Picture 1b (right): Virtual organ Mixtuur Maestro III

ORGAN PRICES

The prices of virtual organ are considerably cheaper than pipe organ. Most commonly, the price of virtual organ is between 15,000 to 60,000 euros, while real pipe organ with up to a thousand pipes can cost anything between 300,000 to 1,000,000 euros. A large concert organ with more than a hundred stops might cost several million euros. Virtual organ audio file banks are a very cost-effective way to study the routine of playing large organ and choosing sounds. Virtual audio file banks for large and high-quality pipe organ typically cost around 700 € and there are already hundreds of different organ on the market with more coming all the time.

SPACE REQUIREMENTS OF AN ORGAN ROOM, REAL AND VIRTUAL

One hundred stops of pipes require a great deal of space around them. The large organ itself requires up to 100 m2 of floor space, as well as a height of ten meters, which means altogether a volume of 1000m3. In addition, the acoustic instrument requires a huge space where the sound resonates. In the large church halls and concert halls, the sound can move and live naturally free. The space requirement of virtual organ is only about 3 m2. A height of two meters is required, which means the need of the space is only about 6 m3. Virtual organ can also be played with headphones, so no squares are

needed at all to play sound in acoustic mode. However, when playing with headphones in a teaching situation, one practical problem is the poor audibility of speech during the play. The headphones direct the sound of the organ directly to the ear, and the headphones also protect other sound from outside, including feedback and instructions from the teacher. It is important to use high-quality speaker solutions virtual organ also use high-quality which allow the student to play and discuss more naturally in the classroom where the organ is. Artificial acoustics can also be built into speaker solutions to simulate a large cathedral or a concert hall.

ORGAN SOUND REQUIREMENTS

While at the Notre-Dame organ loft in Paris with my organ students in the spring of 2018, Olivier Latry, the cathedral's main organist, improvised the organ music at full power, using almost all the organ's 109 stops. The pressure of the sound was enormous, even tearing. I believe some hearing protection would have been needed. At its quietest, using only one of the quietest sounds, Notre-Dame's main organ whispers barely audible sound. The scale of the volume is very wide. In virtual organ implementations, the volume limit consists of the power and quality of the speakers and amplifiers. It can be increased, but since it is very expensive, usually the most enormous voices of the church organ remain a dream. On the other hand, the good side is that in a small classroom virtual organ can be played using even large numbers of stops, and this is done pleasingly to the ears by simply turning the volume knob to quieter. This is also an advantage for the hearing load of the organ teacher and student in a long-lasting teaching and practicing situation.

DIFFERENT ORGAN TYPES IN ONE AND THE SAME INSTRUMENT: NEW POSSIBILITIES

A new dimension in virtual organ is this ability to load multiple organ types. In the small practice classroom, the student gets to know the French Cavaillé-Coll organ with time, their color of the sound, the French stops terminology and the typical list of dispositions of the organ. Likewise, the student learns what kind of playing specialities the Cavaillé-Coll organ has; how many expression pedals, how the Anches pedals work and other details on that type of organ. With just the push of a button, the student can move on to play in a small Italian village church, learn at the old Italian register titles, the split Mixtur stop, the missing pedal divisions and stops, as the more narrow sound field and other details.

When playing Bach's music, student can choose a historical Bach-era instrument made by Gottfried Silbermann from Thuringia, Germany, or an

organ by Arp Schnitger from northern Germany. One can set the original tuning height and tuning system according to the old instrument type, as well as try to change different tuning systems, listen to their effect on the sound and the effect of the chords and the whole piece.

Traditionally, teaching by the pipe organ has been tied to one type of instrument. If the music you are playing is not at all suitable for certain type of organ, you may have need to travel a long way to find another organ from churches or organ classrooms. The music has had to be selected according to the organ in use. The student has gained valuable and authentic experience of different organ types and different spaces as well as differently behaving acoustics. The problem, however, is that access to high-quality organ is very rare, and the actual rehearsal takes place with a small and modest instrument that does not meet the sound and touch requirements of the organ piece which is under working process. The biggest problem is in the study of organ music of the Romantic era, which often requires three manuals, two expression boxes, and a Walze or Setzer combinations, and a hundred stops. Practicing the complex four-limb motor skills of such music is frustrating with small one- or two-manuals containing only few stops. In the virtual organ solution, the student gets routine to the sound and register terminology of different types of organ and gets used to hearing their own sound typical of each piece's stop list, as well as using three manuals and expression pedals, Setzer combinations and other specialties.

ABOUT THE TUNING

The tuning height and interval pitches are permanently set in each pipe organ. Because it has tied to the physical length of the pipes, it cannot be changed spontaneously. In the Renaissance and Baroque eras, typical tuning heights were the so-called Chorton (a' = 466Hz) and Kammerton (a' = 415Hz). The tuning standard (a' = 440Hz) is most often used in our time. In virtual organ, the tuning level can be set freely to any point and try out how it affects the music.

The tuning systems, i.e., the magnitudes of the intervals of the scale tones, are also set permanently in the pipe organ. The tuning systems have been very different, especially during the Renaissance and Baroque. Today, the most used tuning system is "well-tempered" tuning system in which each semitone step is the same size. In fact, the result is not exact, there are too wide third and fourth, and too small fifths and sixths. However, the difference is so mild that it is often not noticed at all. All chords sound the same color. Historical tuning systems differed from modern in that the

intervals formed by the semitone steps were not the same size. Their relationships were defined either through pure major thirds and sixths, or through pure fifths and fourths. It was common for the most used chords in C, G, F, and D major to be tuned to perfectly pure, and the less commonly used chords (Fis major, H major...) were horrible. At that time, composers composed their music to suit such tuning systems, in which case, for example, in some organ choral text, the chord corresponding to the devil's word was terribly quarrelsome and ugly in H major. Today, such colors cannot be heard, because for example the so-called the mid-tone tuning system is no longer built. With virtual organ, these all tuning systems we can choose freely from the tuning system menu list.

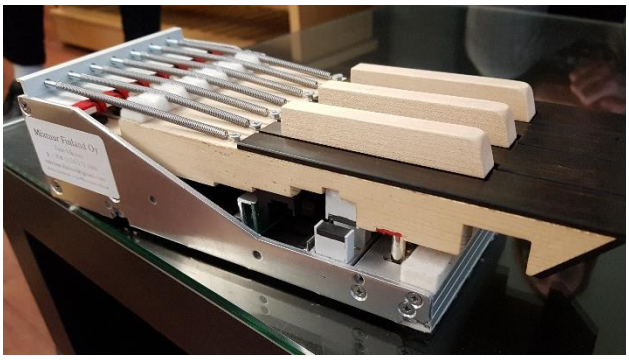
ERGONOMICS

The ergonomics of the virtual organ can be adjusted. Especially when teaching young children this is a useful feature. The keyboard can be adjusted both in height and depth. This is not possible in the case of a mechanical pipe organ. The pedal keyboard can also be moved in a virtual organ and the depth direction and lateral alignment of the pedal keyboard can also be changed. This is also not possible with a mechanical pipe organ. The touch resistance of a virtual organ keyboard can be adjusted to some extent. The adjustment is done by tightening or loosening the spring resistor screw in the back of the keyboard. This is a feature made possible by the German UHT keyboard. In a mechanical organ, this is not possible, because touch depends on which tracker action is used. Choosing a touch for virtual organ is an instructive and a complex process, because so many different solutions have been used in pipe organ.

ON TOUCH

The touch of the virtual organ keys is defined at the ordering stage. One must first decide what kind of touch is desired to be simulated, because there is a lot or variation in the mechanics of a pipe organ. The touch of a tubular-pneumatic and an electro-pneumatic organ is spring-resistant and very light, only 80-100g as well as loose and slow. In a spring-resistance contact, the resistance increases steadily toward the bottom, being slightly heavier at the bottom, than at the top. In a typical and most common mechanical tracker action from the romantic or modern era, the key is quite stiff at 120-150 g, and with the use of manual couplers, the touch resistance still increases, often rising above 200 grams. It has a rigid section in touch when a key is pressed about 3mm, and the touch is at its' lightest when at the bottom, about 40-60g. The sensitive and accurate baroque so-called hanging machine has a strong 110 g threshold when a key is pressed 1-2mm, and the touch is very light after that, only 40 g. Manual couplers mechanically pull the keys

of the second manual down, i.e. when using couples, the touch resistance increases with simple mathematics according to the touch resistance of the manual to be coupled.

Picture 2a and 2b: Mechanical pipe organ (Suomenlinna church) and UHT™ virtual organ keys with contactor switches, magnets and springs.

The touch of virtual organ keys can be formed by combining magnetic and spring resistors. Rubber cup technology is also used. The German UHT-branded keyboard has a touch threshold provided by a magnetic resistor, which can be specified when it comes to its intensity and height when ordering. In addition, there is an adjustable spring resistor which can be screwed tighter or looser at any time. Another commonly used keyboard manufacturer Fatar is a bit cheaper, and its standard touch is the pleasantly soft and light touch threshold provided by the rubber cups. A false situation in both most used keyboard models for virtual organ arises when using manual and pedal couplers. In a mechanical organ, the touch resistance increases when the couples are switched on, as I wrote above, but in virtual organ there is no difference. When playing coupled keys mechanical tracker action pull the keys of the combined manual to the bottom. With virtual organ, the couplers do not pull the keys to the bottom, so the physical feel in this situation is different from a genuine mechanical keyboard. A mechanical organ has large tone valves for large pipes, and small tone valves for the smallest pipes. There is a difference when playing the weight of the bass side keyboards and the lightness of the treble. In virtual organ, Fatar's keyboard is evenly similar throughout the keyboard. In the UHT keyboard, the spring resistors can be adjusted so that the bass side is adjusted to be stiffer than the treble side. In this case, when using this more expensive UHT keyboard, the touch is more similar to a mechanical organ.

ABOUT THE DESIGN OF THE CONSOLE

Different types of organ have different consoles and keys. In virtual organ, you only can choose one keyboard shape from many. In this case, it must be decided whether a compromise is desired with the design of the keyboards

in relation to the shapes of old instruments and more modern instruments. In the old organ, the fronts of the lower keys were about 35-38mm long, where as in an organ built in the 20th century, they are 50-55mm long. Similarly, the shapes of the black keys are different. In virtual organ, you must choose either the leading edge of the black contact at a 30-degree angle, or the leading edge at an angle of 15 degrees according to the old style. The same applies for the design of the pedal keys. There are direct baroque pedal keyboards with high hook-like black keys, or curved 20th century designs with low and beveled black keys. When playing very different types of organ on the same keyboard and pedal with virtual organ, you will be forced into unrealistic situations. The same shape of the keyboard cannot work in an authentic way in all styles.


Picture 3a, 3b: Virtual organ consoles: Mixtuur Maestro III, and the most modern and minimalistic Mixtuur Block Organ



Picture 4a, 4b, 4c: Pipe organ consoles: Kallio Church (Helsinki, Finland), Turku Cathedral (Finland), Norrfjärden kyrka (Sweden)

Likewise, the consoles are very different in different eras. There are differences in distances; in baroque times, the manuals were about 5 cm higher than in the 20th century. There have also been very different ways to set the register switches. During the Baroque, the switches were pullable register pins that were in vertical rows on both sides of the keyboards. In the 19th century, the arrangement of register pins in horizontal rows became more common, and curved console designs became popular in France. In the 20th century, register pins were replaced by swinging switches, and more recently also by illuminated electrical switches. In virtual organ, these cannot be changed afterwards. The pins or switches on the console are such and at the points where they are installed at the factory. The Mixtuur Maestro model specializes in programmable registry pins. Next to each pin is a small monitor with a text telling which stop can be connected from each pin. When you change the organ, these screens are quickly updated to show the information of that loaded organ. Because the layout of the register switches can be freely programmed at any point in the pin row, this Mixtuur Maestro model gets a little closer to each organ. Touch screens are also commonly used to control register switches.

SOUNDSCAPE AND STEREO IMAGE

The natural resonance of sound in a large hall or cathedral when using organ with thousands of pipes is very wide in stereo. Simulating this virtually requires accurate sound modeling, and after all, solutions with a very large number of speakers. Eight directional speakers can in no way replace thousands of pipes, each sounding 360-degree resonance from their place in the 3D sound image. The resonance of the pipes in relation to each other and the cross-effects of sound waves in acoustics are not simple to implement virtually. Development work is needed also to make it clearer at what point the sound was originally born in and where it has left to move in artificial acoustics. In today's virtual organ solutions, the problem with the sound field has been the directional localization of the sound. The sound source seems to be scattered, the echo is unnatural and it is very difficult to find where “the pipe” is. Each pipe of real pipe organ is very easy to locate even in a large cathedral with one-meter accuracy. To achieve this with virtual organ we might need thousands of speakers.

CONCLUSION

Virtual organ bring about a lot of opportunities for studying how to play the organ. The purpose of this article is to shed light on many good and innovative aspects, as well as their current limitations. When I step into a small classroom and into an artificial reality surrounded by several Genelec

speakers, I immediately notice that I am not in a big cathedral. My own voice does not echo at all and I might hear some piano playing in the adjacent practicing room. There is no large pipe organ facade, no gothic arches, thick stone walls, artistic paintings or colourful stained-glass windows around. There is no scent of candles, no benches where the people have sat hundreds of years before us. And no church bells ringing every hour.

The virtual organ is a simulator, creating a good and practical artificial reality to enable routine everyday work. They are a simulator to get used to large instruments, similar to an airplane cockpit in a flight-simulator. But it is also an instrument in itself, sounding and resonating in its own particular way.