# Computer Music Instruments and Live Performance / Concepts related to the Development of an Instrument

Author:
Paul Gruendorfer

Supervisor:
Marko Ciciliani, PhD

Lehrgang Computermusik und elektronische Medien / Institut für Komposition und Elektroakustik

Universität für Musik und darstellende Kunst Wien

November 2013

# Abstract

This paper gives a short summary about the development of electric and electronic music instruments, with the focus on those used in live performances. It shows concepts of compositional decisions and performance practice in the context of live electronic music. Attempts to build a special electronic music instrument for live performances are documented. In this instrument real-time granular synthesis with acoustic input from a modified string instrument (Zither) or contact/piezo microphones, attached on to various objects (cymbals, woodblock etc.) is realised.

This paper is a résumé of the interests and works I have pursued during my studies at ELAK (Institute for Computer Music and Electroacoustics). It should therefore be considered a sketch of my investigations and will not give a complete overview about the themes it covers. However, it includes both, theoretically developed, and in performance practice used, methods as well as pragmatic decisions by myself on aesthetically imposed issues.

# Acknowledgements

Thanks to all the interesting people - within and outside ELAK - who talked to me and shared some of their ideas with me. Considering this work, I particularly want to thank Marco Ciciliani and Michael Zacherl, who gave important insights on the topics it is concerning; and thanks to Igor Linz-Maues, who told me a lot about music and invited me to study at ELAK.

# Contents

# Chapter 1

# Historical Overview

## 1.1 Established and Imagined Instruments

> The evolution of musical expression intertwines with the development of musical instruments [Curtis Roads] [Roa00, p.2].

In principle every object that produces sound could be considered a musical instrument. Their history dates to the beginnings of human culture. The oldest objects that historians refer to are simple flutes, developed approx. 37000 years ago, though determining a specific time of invention seems impossible, mainly due to the instability of the materials used to make them.

While research about the invention of all the diverse musical instruments would have to be done specifically, it is clear that even acknowledged acoustic instruments, that have been adapted and improved over generations, show many variants and idiosyncratic specialties, that change permanently. Nevertheless one could speak for example of 'common western instruments' as stable entities that probably will be around for some time to come, without changing their usability and interface significantly.

In order to write music that can be played by different performers there have to be established instruments, that are in accordance with a generalised notation system.

The composer Helmut Lachenmann phrases his idea about the instrument as follows: *'Composing means: build an instrument'.* A composition resembles playing an imaginary instrument. A whole ensemble can be considered a type of meta-instrument, consisting of the con-sonance of real instruments, that form a complex sound, due to tonal layering and interleaving time structures. So the ensemble is the instrument of the composer [Kas04, p.8].

## 1.2 Utopian Thoughts about Sound Generation

The origins of electronic music can be found in both, the technological development, and in the creative imagination of composers.

> The technologies that are used to make electronic music are a realisation of the human urge to originate, record and manipulate sound. Although the term electronic music refers specifically to music made using electronic devices and, by extension, to certain mechanical devices powered by electricity, the musical possibilities that these technologies have opened up are a recurring theme in literature, art, engineering and philosophy [Andrew Hugill] [Hug07, p.7].

However, ideas of different ways of sound creation are not new to the 20th and 21st century.

Francis Bacon writes in his utopian tale *'The New Atlantis'*, published in 1626, about sound-houses, where sounds and their generation can be experienced.

> ... We have harmony which you have not, of quarter-sounds and lesser slides of sounds. Divers instruments of music likewise to you unknown, some sweeter than any you have; ... We represent small sounds as great and deep, likewise great sounds extenuate and sharp, we make divers tremblings and warbling of sounds, which in their original are entire. We represent and imitate all articulate sounds and letters, and the voices and notes of beasts and birds. ... we have also divers strange and artificial echoes, reflecting the voice many times, and, as it were, tossing it; and some that give back the voice louder than it came, some shriller and some deeper; yea, some rendering the voice, differing in the letters or articulate sound from that they receive. We have all means to convey sounds in trunks and pipes, in strange lines and distances [Bac07, p.43].

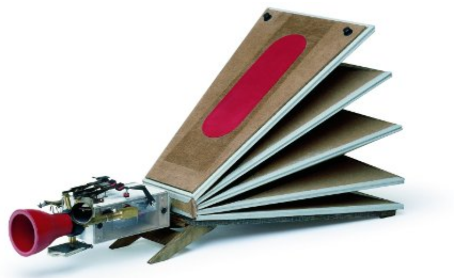
This utopian passage seems to be an anticipated description of a modern sound studio and characterises many of the possibilities a simple audio software and the computer offer nowadays.

## 1.3 Automata

One of the important aspects that distinguish traditional acoustic instruments from experimental or electronic musical instruments is how actuation is created. While in traditional acoustic instruments sound has to be generated by some mechanical action, most of the time performed by the player, electronic musical instruments or even automata of earlier times have their focus on some automated transformation process which generates an audible result.

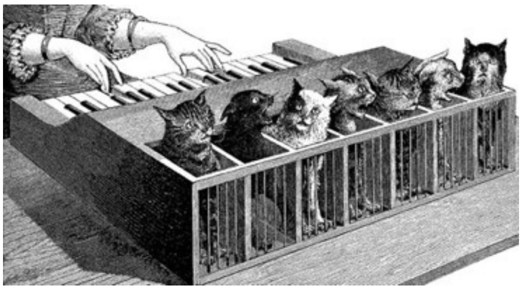
Either it was the search for new sounds that lead to inventions of automata, which were not bound to the actuation by human hands, or it was the fascination of a machine that could produce sounds merely by itself. There are diverse prototypes that have been invented, before the digital area opened up a vast field of automated applications, that are known now.

To name a few: mechanical examples like the Water Organ are already described in the 3rd century BC, where water drives a mechanism so that compressed air blows a pipe [Wat13]. There were attempts like the Pyrophone, using chemical procedures, where hydrogen gas burns in a glass tube, controlled by a piano keyboard [Kla10]. There were robot like machines by Jacques de Vaucanson, capable of playing melodies like a human being, as the life-size flute player (1738) did, or his most celebrated automaton, a duck (1739), that moved its wings, legs and body, quacked and amazingly ate, 'digested' and excreted food. There was a talking machine by Wolfgang von Kempelen (1769), that could mime one to two words and most of the consonants and vowels of the german language, and other life imitating devices like the singing bird-boxes of french watchmakers.


Water Organ Talking machine ( reconstruction ) Mechanical Bird, [Bird Song, youtube][1]

There was also a bizarre idea described by Anthanasius Kircher, which is not known to be realised, that suggested not to take the effort to automate sound, but use a kind of real life sampling to achieve a sound effect - the Cat Organ. Here cats are arranged according to their natural tone of their voice with their tail under the keyboard, to hiss in the right tune when a key is pressed.



Cat Organ

[1] http://www.youtube.com/watch?feature=player_embedded&v=tPKFT_t2rL0

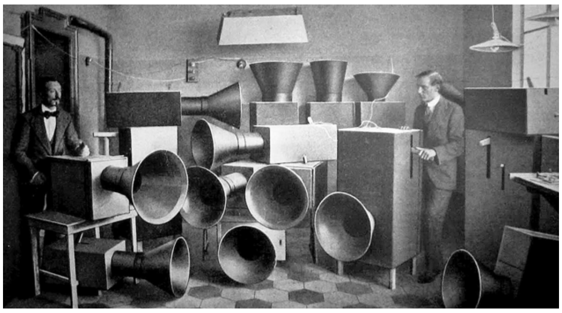
## 1.4 Early Electric / Electronic Musical Instruments

With the increasing importance of technology at the end of the 19th century the possibility to build new musical instruments arose. There have been attempts to use electricity for sound generation before, like the clavecin électrique (Jean-Baptiste Delaborde, 1761), that used static charge to ring bells, controlled by a harpsichord [Hug07, p.10], but inventions as the Phonograph (Edison, 1877) and the Telephone (Bell, 1876), mark a real turning point. The production of sound started to be not solely reduced to the laws of Newton mechanics anymore, once the first signs of sound transformations like recording and to transducing appeared.

Technical inventions have played an inspiring role for individual artists for a long time. But at least since the Italian Futurist movement technical invention became a general theme in artistic and musical practice. The machine is seen as the symbol for a modern and autonomous life. Along with the changes of the sonic environment came the discovery of noise as a musical expression. In 1913 Luigi Russolo constructed the 'Intonarumori', resonators that use mainly mechanical principles, after reading a text of a correspondence between the Dada-movement and the Futurists, a sound-poetic attempt to convey the noises of battle. He tried to categorise sounds and treat them as potential music: rumbles, whistles, whispers, screeches, noises of percussion, voices of animals and humans, which are reproduced by the 'Intonarumori'. His work has influenced composers like Georges Antheil (Ballet Mécanique, 1924) and Edgar Varése (Ionisation, 1931), and he is often regarded as one of the first noise music experimental composers [Rus13].

Around this time electronic music instruments that use sound synthesis such as the Theremin (Lev Termen, 1919), the Trautonium (Friedrich Trautwein, 1929) and the Ondes Martenot (Maurice Martenot, 1928) started to appear regularly in concerts [Hug07, p.18]. They are among the first inventions of electric / electronic music instruments, that made the step, to be recognised by a larger audience, and into the history of musical instruments.[2]

Theremin



[Intonarumori, youtube][3]

[2] A detailed list of instruments can be found in the book *'Microsound'* by Curtis Roads [Roa00, p.45]).
[3] http://www.youtube.com/watch?v=Lqej96ZVoo8

## 1.5 Record - Transduce, Microphone - Loudspeaker

> According to Jacques Attali, the power to reproduce sound used to belong to the gods - with over 5.3 billion mobile phones now in use, that power now belongs to most of humanity [Ste12, p.1].

The ability to record sound and diffuse it at any time or place, has a radical influence on the practice of music performance, and more general, on cultural questions as well. Walter Benjamin writes about reproduction:

> . . . reproduction can put the copy of the original into situations which would be out of reach for the original itself [TrR12, p.209].
> . . . it emancipates the work of art from its parasitical dependence on the ritual. (The ritual to which he refers to is the performance, a unique set of circumstances under which the individual or a group experiences a work of art [Hug07, p.14]).

While microphone and loudspeaker open up transformation processes between the source and the resulting sound, the record makes it possible to separate sound from its original acoustical source and reproduce it spatially and temporally independent. Volume and spatial position of the sound source can be varied. Today this phenomena seems obvious, as it is integrated into the western cultural practice, and most of the music perceived today is transmitted through media. But the relation between sound creation and sound event has some essential aspects like presence, causality and gestural impetus of player and instrument, when it comes to the perception of a live performance.

The radio is the first device of mass media that changed the listening modes of a greater public and started to dissolve the bound of source and sound sensation. With the radio transmitter/receiver the access to information became universal. Therefore this media was used to spread the word to an unknown, unlimited audience that could be reached immediately. But contrary to the immediacy the internet offers today, the radio is also bound to the specific moment in time, meaning it is only available when the program aires. Probably due to this fact, a kind of collectively shared experience of simultaneity is generated, an *'imagined community'* [Hil12, p.351]. Besides the consumers choice for trivial entertainment and leisure decisions, this created a 'voice' which could be heard around 'the nation'. Due to the specific quality of the medium, the Radio simulated an intimate experience. Suddenly there was a broadcasted 'voice' in the living rooms of the listeners, talking to them in private. This is an important factor considering for example the political purpose the radio was used for, the creation of a time synchronised anonymised ritual.

Eventually, the close relationship of the radio to the 'time parameter' motivated John Cage to compose Imaginary Landscape Nr. 4 (1951) or Radio Music (1956), which uses the diversity of broadcast sounds that are selected by 8 different performers following the score, leaving his often used chance operation to the immediate simultaneous occurrence of the media itself. This could also be seen as an indicator for the different possible utilisations of electronic instruments or devices in electronic music at the time. John Cage can be considered among the first composers who wrote pieces for live electronic music, meaning that the sound is created in real time at the concert. Two well known pieces are: Imaginary Landscapes Nr. 1 (1939) for piano, percussion and 2 turntables playing records with test-tones, and Cartridge Music (1960), where sounds are produced using cartridges from record players, that are manipulated by inserting different objects into the opening of the cartridge so that amplification of quiet sounds, referred to as 'small sounds', emerge. This introduced gesture and the performer into electronic music at a time when the latter was confined to playback works, that are prerecorded on tape [Her13].

Other compositional concepts used a 'fixed media' approach for electronic music composition. It was mainly shaped by prerecorded or synthesized material, which was transformed with effects like reverb and sent through filters or was rerecorded for example with variable playback-speed; the result was then stored on magnetic tape. When being played at concerts, the tape reproduced an already formulated result, that didn't need an interpreter. However, the room was discovered as an additional means of expression, and multichannel diffusion started to come into focus, adding the chance to interpret the fixed composition when it was performed. At the premiere of Pierre Schaeffer's Symphonie pour un homme seul in 1951, a system that was designed for the spatial control of sound was tested. Induction coils were used to control sound spatially for acousmatic music [MCo13].

Although playing with modified recording dates to early experiments, e.g. from Dziga Vertov in 1918 and other composers like Paul Hindemith or Darius Milhaud, who experimented with variable-speed phonographs in the 1930s, it is in the 1950s when this practice was categorised as Acousmatic Music which is connected to Pierre Schaeffer's Musique Concréte (1948), the counter element to live electronic music. There were two studios that defined the electronic music production in Europe during the 1950s. In Paris, the 'Groupe de Recherches de Musique Concréte' (GRMC), which was later called 'Groupe de Recherches Musicales' (GRM) and in Köln, the 'Studio für elektronische Musik Köln', were both engaged in tape composition, but disputed over the source material: microphone recorded sounds, Musique Concréte used as starting point versus synthetically generated tones, used at the Studio in Köln. This is also to be seen in correlation to aesthetic rivalry between musique concréte and serial composition concepts. The dogmatic views between Paris and Köln loosened at the latest when Karlheinz Stockhausen realised the compostion 'Gesang der Jüngelinge' (1955/56), which combines material of a recorded voice of a boy soprano and electronically generated tones. But then there arose the question how to bring those new found methods of the studios onto the stage to perform electronic music without prerecorded material.

## 1.6 Commercial Synthesizers and their Interfaces

Another reason for the wider use of electronic music instruments could be the appearance of the first commercial synthesizers, that became available to a larger group of users. Prior to that only an elite of composers had access to the studios to work with electronic tone generators. With affordable synthesizers electronic sounds could be created by performing musicians themselves and thereby found their way to different popular music genres. Robert Moog released a voltage controlled subtractive synthesizer to utilise a traditional keyboard as controller (1964), while other systems like the Buchla experimented with control interfaces, such as touch sensitive plates. The Moog models with the keyboard were commercially much more successful, as they were easier to operate for trained musicians and resembled traditional instruments [PiT12].

The more experimental approach like the control surfaces of Buchla, were preferred by artists like Morton Subotnik and Vladimir Ussachevsky, but also demanded different playing methods, and needed curiosity for an 'unknown outcome'.[M.Subotnik, youtube][4] It is interesting to see how an interface also changes the focus of an instrument and how invented systems, once tested and used by many people, are established as a 'stable entity'. Morton Subotnik states: *'[. . . ] Once an invention is out there used, people getting used to it [. . . ] like the 'QWERTY' layout of the computer keyboard'*. (Although other computer keyboard layouts than the QWERTY would produce faster and more efficient input, the QWERTY system is so commonly used, that it is too late to change it.)

## 1.7 Computer Music and Real Time Audio Synthesis

Parallel to the technical development of circuits using individual components like diodes and transistors, the production of integrated circuits (ICs) began. The exact moment when 'circuits' grew into 'computers' is hard to pinpoint [Col07, p.48]. The first microcomputers were too slow for real time processing of audio signals, but they were used as controller units for analog hardware instruments (synthesizer, sequencer, drum machines etc.). To interconnect synthesizers, or to communicate with an interface the digital protocol MIDI (Musical Instrument Digital Interface, 1982) was introduced, a system for sending data and synchronising information between devices.

[4] http://www.youtube.com/watch?v=ach9_OKHOCA

It took until the 1990s that real time systems for computers are used, mainly due to the increasing processing power of personal computers. Until then computers were used as a tool for synthesis or score generation and algorithmic methods, but were working in a kind of 'deferred time' meaning a considerable period was needed to complete the process.

Historically, the first composers using computers were trying to generate structures, e.g. Iannis Xenakis computed velocity trajectories for glissandi for his 1954 orchestral composition 'Metastasis' and produced data based on densities and probabilistic distributions for his stochastic compositions. Lejaren Hiller and Leonard Isaacson wrote a number of algorithmic compositions where the whole score is generated by computers, starting with their string quartet 'Illiac Suite' (1957) [Ble11, p.5].

The early experiments with digital audio synthesis were done by Max Mathews at Bell Laboratories. At that time he developed the first music related programming languages (1957-1968) Music I -V, that until today serve as model for computer music programming languages. The system consists of two parts: the audio synthesis engine and the control engine, operating the synthesis. It works with building blocks (Unit Generators) that are interconnected, kind of simulating a classic analog studio using sound-, envelope-, random-generators, adders, multipliers and filters etc.

Miller Puckette used the same principle when developing the software 'Patcher' at IRCAM (Institut de Recherche et Coordination Acoustique/Musique, Paris) for the realisation of a composition of Philippe Manoury. It could process MIDI data and connected to the real time signal processing engine FTS (Faster Than Sound) that run on a Next Computer (1986-89) for the audio part. This is the predecessor of graphical audio programming languages like Max/Msp[5] and Pure Data[6](Pd), that use graphical objects which can be interconnected to form data-flow graphs for audio signals and control messages. In 2002 James McCartney released SuperCollider[7] under GNU General Public License, a very modular system, based on an object-oriented dynamic programming language, where similar to the old Music-N program family, commands are written as text. Those are just a few examples of a multitude of software programs for real time audio processing. With those steps the computer music started to have similar options of sound manipulation as analog solutions, with the advantage of direct disposability.

Now it is possible to build whole new instruments that run on a small portable laptop and connect two generally separated disciplines: composition and studio production, and live performance. But whereas in the studio everything can be rethought and adapted twice, it is necessary to work fast and intuitive when playing live [Kas04, p.21]. Questions on how the interface works and how to perform those new 'invisible' computer instruments arise.

[5] http://cycling74.com/
[6] http://puredata.info/
[7] http://supercollider.github.io/

# Chapter 2

# Interface Design and Live performed Electronic Music Instruments - Listening Concepts and 'Theory of liveness'

## 2.1 Interface Design and Live performed Electronic Music Instruments

What a radio emission of the 1920s accomplished - transferring content of one specific program at a specific time - the computer can provide in real time in diverse dimensions: collect and layer, reorganise and reproduce, particularly synthesize any contents essentially without the restriction of the guidelines of institutions, or studio owners. It becomes a kind of private multidimensional studio instrument, without any other constraint, than the available technical knowledge.

The computer offers an infinite sonic universe, compared to the special limitations of traditional acoustic instruments (timbre, resonance of physical material, mechanical restraints etc.). But the main distinction between computer and acoustic instruments lies in their control mechanisms - how they are played, respectively used. With the computer it is indeed possible to automate and supervise all parameters simultaneously, vary them continuously or abruptly, whilst the performer of acoustic instruments has to address physically every small control change - every nuance makes a difference. But the trained musician, which has the skill of playing the instrument, can adapt quickly to different situations and playing techniques within the scope of the instrument. To achieve the same differentiation with a computer, every detail, if it is within a live instrument or in the course of a studio production, has to be told the computer in advance.

So the aspect of parameter modification and variation is essential to control computer generated sounds. This is especially important, when the sounds are not produced in the realm of the studio, but are generated within a live instrument, where there is no time for fine grained re-adjustments.

The well known term 'interaction' which is often mentioned in context of new media works, sound installations and music performances, describes the difficulties that have to be dealt with considering the design of computer instruments. Music, that has always been an 'interactive activity' (musicians interact with their instruments, with other musicians and with the audience), shall now be produced in a singular kind of 'black box' where all the magic happens. Ironically enough, interactivity actually suffered due to technological advances attained in the nineteenth and twentieth centuries. Recorded music for example eliminated the feedback dialogue between the audience and the live musicians, turning music performance into a one-way communication [Jor07, p.91]. The same is true even between musicians, as multitrack recording eliminated both, the spontaneous dialogue between different players, and the possibility to adapt to unforeseen situations.

So how can, respectively should, this loss be regained with computer music instruments?
When we look at the currently generally available options to control the computer, there are many different possibilities besides the already integrated interfaces (like mouse, ASCI-keyboard, trackpad, screen). Here are three main categories of controllers:
- instrument like controller (imitating traditional instruments like keyboard, trumpets, guitars, drums etc.)
- extended controller (traditional instruments with added sensory input)
- alternative controller (with a number of possibilities: non-contact gesture, wearables, haptic etc.)

Regarding the questions I had to deal with designing interfaces for computer music instruments, the main challenge with all those options is to overcome the fact that every input parameter coming from the controller can be arbitrarily assigned to any sound or musical process. This can be considered an advantage for studio production, but when it comes to building a computer music instrument this also leads to some additional questions besides simply controlling the sound. It also indicates aesthetic or conceptual decisions of how an instrument is perceived when it is performed. A transparent relation between playing a controller and the emerging sound is not self evident as there are no obvious mechanical principals involved for sound generation. Of course one doesn't have to follow the path of traditional instruments. So if the interface solely offers a 'start button' this might be a valuable option for certain performance situations.

But in order to function similarly to a traditional instrument, the controller must establish either a previously known transmission system, e.g. mapping the piano key to a certain pitch, or a new form of trigger-action syntax has to be invented. But to establish functioning systems is a complex task, when the rapid development of new devices, or modular structures to adapt to additional ideas is taken into account. It is rare that new interfaces in the stage of development are tested by others than the creators themselves, and most of the time their setup changes too rapidly for intuitive and virtuous playing techniques to be learned.

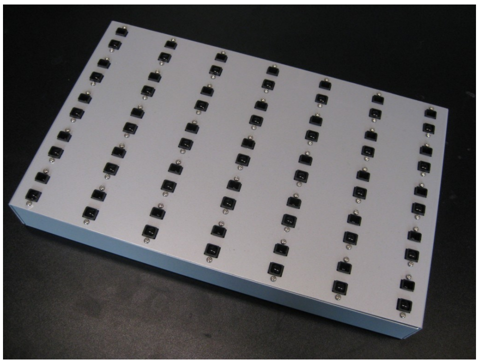
So the questions revolves around designing a stable setup with limited possibilities, which can be understood and thereby learned to be controlled; - whether instruments offer 'resistance' and feature an individual character. It is the reduction to a few parameters that nevertheless offer a large variety of expressions and nuances in their output, that make an instrument playable. A good instrument should also be able to produce 'terribly bad' music, either at the player's will or the player's misuse [Jor07, p.104].

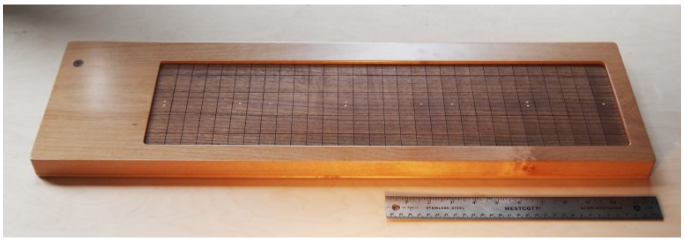
Some examples of alternative controller interfaces:

Gestural Controller, 'The Hands', [Michael Waisvisz, youtube][1]

Breath and gestural Controller, [Onyx Ashanti, youtube][2]

[1] http://www.youtube.com/watch?v=pYfRORkuPX8
[2] http://www.youtube.com/watch?v=JataQs4R5Bc





Infrared controller, [Chikashi Miyama] Touch sensitive controller, [Madronalabs]

Whether an interface is suitable for certain computer generated sounds probably has to be answered on several levels. For example Michael Waisvisz criticises that there is no development on systematic coherent gestures and that feedback between controller and music is ignored.

> A growing number of researchers/composers/performers work with gestural controllers but to my astonishment I hardly see a consistent development of systematic thought on the interpretation of gesture into music, and the notion of musical feed-back into gesture. [Michael Waisvisz (2000)] [Jor07, p.100]

And Sergi Jordà remarks:

> New standards may not be essential for the creation of new music; perhaps even the concept of a musical instrument is just an old romantic burden, that would be better left aside, . . . but somehow it seems that some unrestrained potential is being eschewed in this lawless anything-goes territory [Jor07, p.100].

## 2.2 Listening Theories and 'Theory of liveness'

Why is it that some musicians want to bring the computer onto stage to play live generated electronic music? It seems rather difficult to build a computer music instrument that can reach the entirety of an acoustic counterpart. So where originates the desire to use them in a similar way in the live context? At the centre of this question stands the discourse about how music is perceived when it is presented.

Pierre Schaeffer gave his book *'Traité des objets musicaux'* the subtitle *'essay interdisciplines'* to emphasise that sound and music could not be understood through one single theory only. To describe the perception and impact of music, he also included aspects that are located in other disciplines like cognitive science and psychology. But his primary interest lies in music perceived as an isolated acoustic event, without the distraction of visual information, music that achieves its effects solely through the sound itself. (This applies both, for the production of sound [meaning the intended split of sound source and resulting sound object], as well as for listening to the sound without observing how it is produced.) In short: the listening experience counts and we don't need to know what causes the sound - we need to apply what Pierre Schaeffer calls reduced listening (Écoute Réduite) [Sch13].

Michel Chion writes about the acousmatic concept:

> Acousmatic: ' ...indicating a noise which is heard without seeing the causes from which it originates. ...The acoustic situation renews the way we hear. By isolating the sound from the "audiovisual complex" to which it initially belonged, it creates favourable conditions for a reduced listening which concentrates on the sound for its own sake, as sound object, independent of its causes or its meaning ... [Emm07, p.5].

This idea reminds one remotely of the concept Richard Wagner implemented, who hid the orchestra in his self designed orchestra pit for the 'Festspielhaus' in Bayreuth. This way he tries to exclude the *'mundanities of physical production'* [Emm07, p.4] in order to achieve a sort of absolute music, an immersive condition.

But what happens with the associations and meanings that sound produces when it has references to the human environment nowadays: the jingles of the news shows, mobile phone sounds, sound 'signatures' of public transport, rhythmic patterns etc. that leave their traces in the collective mind.

While Pierre Schaeffer's interest lies more in the internal structures of sound itself, where the context of the creation of the sound is rather disturbing, other musicologists follow a different interdisciplinary method and focus on the research of various categories that affect sound and its surroundings. They understand music applying a semiotic or anthropological approach, and don't consider music as an aesthetic self defining system. For example, Jean-Jaques Nattiez refers to the 'total musical fact' that comprises tonal aspects of music equally to social or cultural conditions, and Christopher Small even states that music as a separated media doesn't exist, but rather is a social cultural activity [Cic13].

So, is it possible to perceive music without the context within it is happening?
When you look at a live-performance with human protagonists there are some effects that come into play, that seem to have an important part in the reception.

Simon Emmerson created three classifications to differentiate the consequence that interfere with each other and are simultaneously interacting. He calls them different aspects of 'presence' [Emm07, p.2].

- Physical Presence: Action and Agency
The expectation that every gesture of the performer is an action that triggers a musical reaction. A causal relation is assumed, even if there is none. Acoustic events are determined by the forms, shapes and materials of their source and the reflection of the room. Electronic sounds can be transformed by those parameters independently, but still are conceived as being dependent on the performer's actions.

- Psychological Presence: Will, Choice and Intention
The causal relation is also connected to the wish to categorise and predict the next move. Thereby it is a general assumption that choices and changes of the performer are planned or improvised intentions and so the performer is simultaneously the author. Musical structure can therefore be peculiar to a particular cultural group, that has the expertise to predict and decipher the 'codes' used in music. It is part of an ongoing reference process that results from whatever participation in the event.

- Personal and Social Presence:
This is also an important factor, because most of the time the audience somehow relates to the performer as a 'protagonist'. The connection between music, performer, time and place makes the listener switch the roles and connote the movement of others as his/her own. In cinema theory this is known as 'persona', where the spectator identifies with the main character, which leads the storyline.

Besides these categories that affect the listener more than the musician, there are also some resulting aspects, that have impact on the usability of electronic live instruments; e.g. if nobody notices the difference between playback and real time performance, what a difference does it make then? In the article 'Theses on liveness' John Croft [Cro07] writes about the constellations that occur, when in a performance acoustic instruments are further processed with live electronic devices. John Croft gives a detailed listing about relations between the acoustic and the electronic part, and differentiates accompanimental, responsorial, environmental, instrumental etc. relations between them. He suggests that there has to be put more thought on the difference between what he calls procedural liveness and aesthetic liveness. It is necessary to ask whether live transformations are also perceived as live and whether instruments still function in this context.

Finally, what does it come down to when asking why to perform live electronic music? As there seems to be a gap between bodily presence and disembodied sound, it is the interest to combine those opposed poles.

# Chapter 3

# Live Granular Synthesis with an Acoustic Input Source

In this chapter the development of an electronic music instrument is described. I built this instrument to use it for live performances. The setup I describe is the result of numerous attempts to implement real time processes that run on the computer using an acoustic input signal as a source.

I became interested in live generated electronic music, without thinking about the structures behind it. I was fascinated by electronic sound, that - generally composed and shaped beforehand -, seemed to have surprising and unconventional results when generated in real time. I considered it a plausible wish, to perform electronic music with the same attitude as when playing an acoustic instrument. Probably I was also influenced by the way perception is 'diverted' when a performer is present. Different categories of 'presence' are described in Chapter 2. This interest was based more likely on an idea, that there are different correlations I want to think about, than on a conscious aesthetic or artistic decision.

This chapter is divided into the following parts:
Part 1 explains the different sections of the setup and the technical implementations. It summarises how live granular synthesis with different acoustic input sources is used.
Part 2 describes how the interface and the conception of parameter mapping determines the functions and playability of the instrument.
Part 3 sums up some thoughts about the motivation behind building this instrument mainly considering the aspects of live performance.
Part 4 gives a short conclusion.

## 3.1 Description of the Musical Instrument using Granular Synthesis and Acoustic Input

This section sketches the main idea for using real time granular synthesis with acoustic input. A complete overview about granular synthesis techniques can be gathered in the book 'Microsound' of Curtis Roads [Roa00]. There is another informative introduction to granular synthesis with SuperCollider by Alberto de Campo [Cam11].

The main three parts of the music instrument are:
- Sound Processing (granular synthesis realised in SuperCollider running on the Computer)
- Acoustic Input (e-Zither, cymbals, contact microphones, microphone input of other sounds)
- MIDI Controller (a simple MIDI Controller, without making use of the computer screen for information feedback of the current status)

The idea for this setup arose when listening to the compositon 'Metastasis'[1] of Iannis Xenakis. Especially the first and the last part interested me. It is composed with the 'sound-masses' produced by the string section of an orchestra, which play stochastically distributed glissandi movements, interrupted by percussive attacks. I was 'mesmerised' by the simple but powerful structure of the piece and its sound aesthetic.

I experimented with string instruments processed with a kind of layering to find some of the density the sound aesthetic of 'Metastasis' exposes. But to reach the complexity of the movement of glissandi and variable dense sound layers, I had to find an instrument with a lot of strings to get vibrating and diverse sounds with different pitch. Also a form of processing that could react immediately was necessary. I thought of a similar sound aesthetic like granular synthesis produces, but with the possibility of fast changes and movement. As an instrument with many strings I chose a Zither that I adapted in such a way as to pick up the sound of each string. As I found a short description of live granular synthesis I could start working to combine those parts.

The synthesis part function as follows:
- Initial point for the live granulation part is the 'The Guitar-Granulator' Martin Huenninger built for a [guitar stompbox][2].
- The main idea is to use a ring buffer to record the audio input. Depending on the parameter values for the granulation process, the audio material is taken from the current input (the actual pointer in the ring buffer, or from events that were recorded before) to be further processed. Hereby the minimum delay time in relation to the the current input position (delta t) has to be defined. I specified it as delta t = (1/2 of the window size of the grain) * playback-speed.

[1] http://www.youtube.com/watch?v=SZazYFchLRI
[2] http://vimeo.com/48738498

- The synthesis uses synchronous and/or asynchronous granular synthesis techniques. Both, fixed and variable trigger rates of the grains can be selected.
- The implementation is for 2-channel systems. Every grain can be distributed between the two channels. The distribution can be spread from a centred position to a random spatial dispersion within the stereo field.
- There is a parameter for pitch shifting of every single grain (e.g. pitch dispersion with a random factor).
- Interval relations can be generated when pitch shifting consecutive grains in a sequential order (e.g. pitch shift sequence for consecutive grains: 1, 1.34, 2.5, 1, 1.34, 2.5 etc.). For glissandi movements blending from one state to another is added.
- Different envelope shapes can be chosen to change the spectrum of the grains.
- The duration of the grains can be modified with an low frequency oscillator (LFO) that multiplies the given grain duration.

After the granulation process there are several effect units that involve reverb, distortion and lowpass-filters. There is also an additional resonator, and - for distorted output - a Chebyshev transfer function is used.

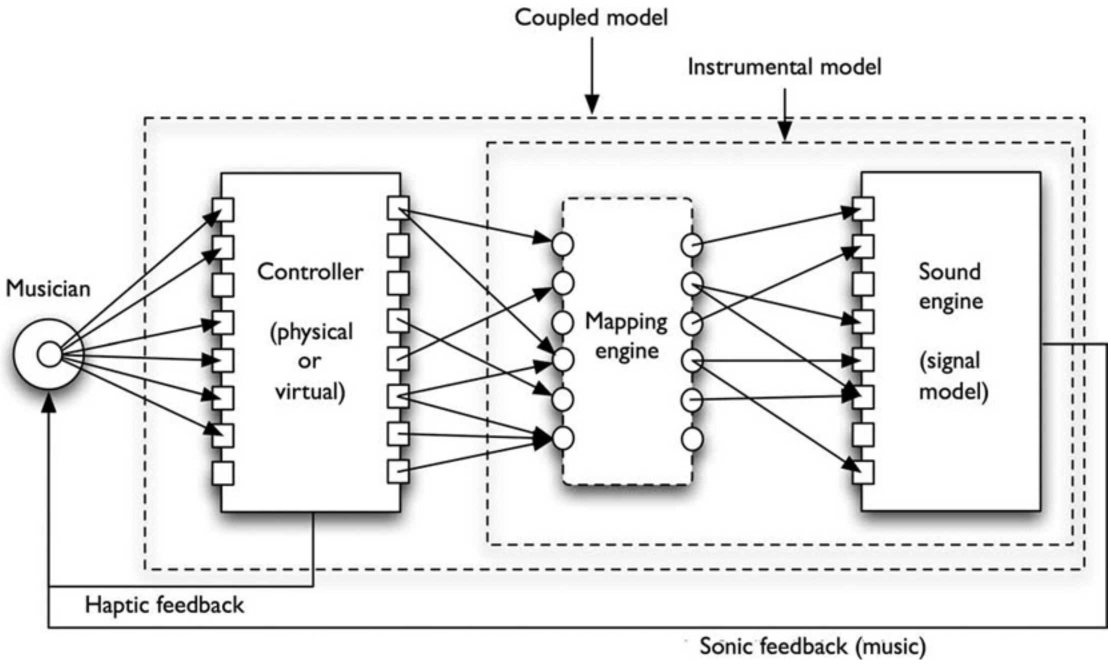
The acoustic part functions as follows:
The first design was realised with a modified Zither. The instrument was cut in half, so that only the fingerboard and the first six accompanimental strings remained. This was done to make it transportable, and more important, to insert single coil guitar pickups for sound recording.

e-Zither

With single coil pickups it is possible to record sound without feedback. Otherwise the processed granulated sound would be reintroduced into the recording stage. When playing with other objects like cymbals or wooden plates contact/piezo microphones are used. This is an option to record almost silent 'microsounds' and to gain a kind of haptic control over the instrument.

cymbal with a piezo microphone

## 3.2 Interface design - Parameter Mapping - Constraints




Typical model of the musical interface (Wanderley 2000; Leman 2008; Wessel and Wright 2001), quoted by Thor Magnusson [Mag10].

Designing the interface for an electronic music instrument is a gradual and iterative process. As there is a split between the interface and the sound engine, it has to be done in a regular interchange with the sound processing part. *However, problems here include the practically infinite expressive scope of the environment ...* [Mag10, p.62]. To filter out the essential parts, constraints have to be found successively to narrow down the instruments functions. Otherwise it would be impossible to make it playable. Thor Magnusson writes about the different forms of constraints concerning instruments:

> Physical constraints define what can be performed with the physical environment [. . . ] Logical constraints outline how human logic inductively informs us about the environment [. . . ] internal constraints, the logical possibilities of how the piece can progress according to the rule set that has been implicitly or explicitly set; and external constraints, the need to be sure that the piece is physically possible for a performer [Mag10, p.64].

An important aspect of this instrument is, that it has no graphical user-interface, which a user of computer music instruments often needs, to interact with. This instrument functions without the screen of the laptop. The decision against visual feedback when controlling the instrument, eliminates complex operations, and more important, it directs the focus on to listening to what is played.

Computer music instruments don't give a direct acoustic feedback. The computer doesn't have a sounding body, so there is no haptic feedback when playing a controller, other than the surface of the controller itself. This is a crucial factor for this instrument, using acoustic input from musical instruments (e.g. e-Zither) with haptic qualities, and of contact microphones, which can be adjusted. I call it a kind of 'haptic controllable synthesis'.

This results in the reduction to a few effective controller parameters. When mapping parameters is is necessary to decide what is flexible, what has to be fixed, and if there is a dependency between different parameters. For example, in this instrument the effective 'grain duration' for the granular synthesis is calculated from the 'duration' and the 'overlap' parameter. And five different 'envelope shapes' can be selected with turning one MIDI controller knob.

There is a multitude of intertwined, successively taken decisions that form the identity of the instrument. Each decision constrains the instrument in one way or another. But those restraints enable playing techniques which produce unforeseen results.

I want to conclude this section with two quotes by Thor Magnusson:

> The primary virtuosity [in playing an electronic music instrument] is not at the level of the instrument itself or in the relationship between the agent and the object, but rather below the instrument at the strata of hardware and code [. . . ] Considering all the available parameters and functions, mapping should be defined as a compositional process that engenders a structure of constraints [Mag10, p.70].

> In the field of digital instruments, designing an instrument often overlaps with the musical composition itself (or at least designing its conditions) [MaM07].

## 3.3 The Motivation for building a Live Electronic Music Instrument

Is there a need to invent a music instrument before making music?
I remember a statement I once read. Paraphrased it reads approximately like this: *'music instruments are cages for the sound they produce'.* To express it differently: every instrument is characterised by a particular set of limitations. The main reason why I am attracted to electronic music, is the thought of apparently unlimited possibilities to combine sounds - to think of sound as a material which can be shaped in multiple ways and does not impose a fixed form; similar to the way artists or experimental filmmakers work with material, but without the restriction to produce it in advance. How is this achieved, without getting lost learning an abundance of techniques and/or getting caught in a meaningless showoff of 'what can be done'?

Commercial electronic music instruments and ready-made proprietary software packages offer a lot of possibilities to work with, but they seem to impose the same fixed ideas on sound production as other music instruments. So in order to accomplish more flexibility to adapt concepts, or conduct experiments, it is necessary to find a toolbox to work with. Real time audio software like SuperCollider, Pure Data (Pd), Csound or Max/Msp (to name but a few) offer a development environment to search for previously unavailable coherences that are not disposable in commercial software packages, plugins or pre-built electronic music instruments. This concept takes much longer to yield a result, but for me it feels right to work that way. Also helpful and inspiring is the community around open source projects like SuperCollider[3] and Pure Data[4], which provide support when technical problems arise.

What is the argument for a live electronic music instrument?
Above all - not to be restricted only to traditional studio work. There is a different musical result when controls can be modified in real time. It is easier to find organic structures when sound is generated directly with a musical instrument, then to work with recorded material, which has to be adapted. Also the thought process is completely different to arranging or composing in a 'deferred time'. It is difficult to separate the design process of a music instrument and the stage when playing it, as it is evolving and interconnected all the time - but it is conceptually

[3] http://supercollider.github.io/
[4] http://puredata.info/

and mentally separated. Though one constantly has to switch between creating tools and using them.

> There is on one hand the usage of tools, where the tools are ready-at-hand and are applied [by the musician] and, on the other hand, the moment when the tool breaks and it becomes present-at-hand, i.e. the user of the tool has to actively think what is wrong with the tool, and look at its mechanism from a new and critical stance [MaM07].

Playing a self designed music instrument challenges the proposed ideas and sometimes points to surprising areas. In order to be able to play musical instruments, constraints have to be designed. Therefore, using those specific instruments for a composition results in also having constraints within a piece. This can point in a direction and help to find a thematic or material to work with, similar to when composing for traditional instruments.

Why performing with electronic music instruments?
Music has been a communicative media and a social activity ever since. Over the 20th century the mode of listening to music changed from the necessity of the live concert to an ubiquitous availablity of diverse forms of music through media. The ritual of music performance can now be bypassed, which has the positive effect to have access to diverse forms of music. The internet serves as a great pool, where everybody can easily find diverse new styles of recorded music, without being restricted to the taste, or concepts of an institution, the program of a concert hall. But where do the ideas for music come from? They must come from communication and sharing knowledge with other musicians, composers, producers or instrument designers etc. To find those one doesn't even have to go to concerts, but just sign up in a mailing list or watch tutorial videos. But this alone seems quite remote from the original intention of music. Of course there are concerts taking place in established concerts halls and institutions that existed before our time, and electronic music also takes an important part in modern and contemporary composition. But when looking at more experimental electronic music, it can also bring together the following contradictory practices:
- the 'lonely process' of the individual as a composer, experimenter or instrument designer with the vast possibilities of sound generation,
- and the social interaction and confrontation of live performance with other musicians.

I do not want to claim improvised or live generated electronic music as a revolutionary concept of performing music, but for electronic music this offers an opposite standpoint to the reflections and thoughts that have to be gone through before playing (concerning the 'compositional' aspect of electronic music instruments).

Here a some considerations:
- 'Playing live' is a possibility to communicate with other musicians and the audience within a given context.
- Live performance is a kind of time synchronisation in a multimedia society. Sound as a time-based media can be experienced immediately, at the time of its emergence.
- Live performance is a process to learn how to react to changes and follow the movement and ideas of other musicians. When electronic music is played live, there is also the risk to play something previously unintended.
- Does it sharpen the perception? - maybe this applies just for the musicians themselves, but it lifts the experience into the notion of the 'now'.
- Whether electronic music is played live or comprises precomposed playback parts, considering the musical results, both approaches follow different aesthetic theories. Live generated music is limited to the actual possibilities of the instrument and therefore produces a 'particular musical statement'.
- Live generated music can just be perceived as a whole experience at the moment it is created. It is not primarily made for distribution, or as a product. Contrary to the abundance of existing music, this is limited to what is happening at the performance.

## 3.4 Conclusion

To work with programming languages opened up the possibility to experiment with ideas, that I could not pursue before. Many exiting musical results can be achieved by using already existing musical instruments, or tools. But it is difficult to make them available or to know in advance which one is suited without prior testing. So trying to concretize the essential ideas with real time audio software, helped me to get some insight into electronic music. The experiments to develop instruments for sound generation opened up new experiences, gained step by step, on how sound material can be generated.

The main reason for this decision, was to work with sound and form, that don't impose a preconception of a 'correct way' to work with. This method is not primarily shaped by the long history of already used musical instruments and compositorial structures.

Ready made instruments are parts that are available for the development of further ideas. Of course self made instruments take some time to build, but they provide the chance to implement/test ideas directly. They offer a kind of controllable tool for imaginations. When 'programming' an instrument, everything can, or has to be controlled, which sometimes is a drawback when wanting to 'get things done'. In exchange small insights can be found that lead to new perspectives. In contrast to 'programming' there are conceptions like circuit bending, or opening-up existing instruments to modify their functions. Maybe this approach is similar in its desire to play with material, that has it's own meaning. However, there are different opinions on whether 'meaning' is created by an idea or with the material it is formed of.

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