sound plates as piano interface

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ABSTRACT

The vision of “dancing music” is quite old and a lot of interactive implementations playing instruments with dance have been tried out. This interface of a dancer playing piano has targeted to the music-theater performance “Maschinenhalle #1” for 12 dancers, 12 sound-plates, 12 robot pianoplayers and control station. The unit of dancer-soundplate-pianoplayer as interactive instrument has been developed with the choreographer Christine Gaigg and the composer Bernhard Lang within an artistic research process and has turned out as being a kind of machine unit, including the dancer as worker. Here the development and exploration of this machine is shown.

Topic and Subject Descriptors

D.3.3 [**machine musician interface**]: musical interfaces, complex systems

Keywords

robots, music instrument, transcription, composition

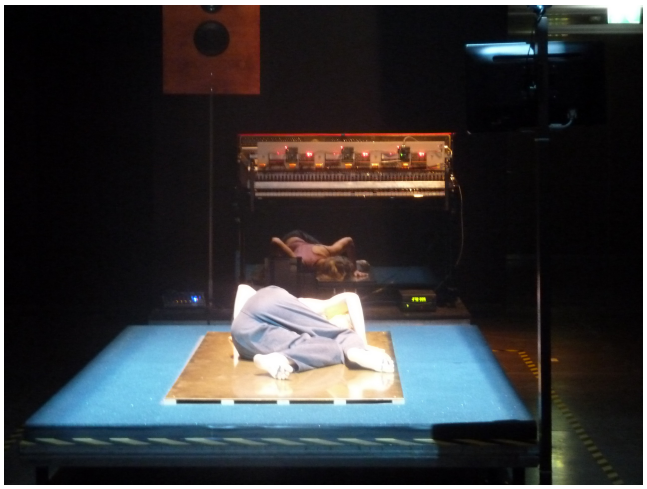

figure 1: dancer,sound-plate and piano at performance

1. INTRODUCTION

Using sound plates for dancer has been realized in the last ten years within the performances “V-Trike”, “TrikeDoubleThree” and others developed with the composer Bernhard Lang and Christine Gaigg within the series of “difference and repetition” at various festivals[1],[2]. Within these pieces restricting the interface for dancer interaction on a plate, driving a surrounded multimedia environment and utilizing the sound of the metallic sound plates equipped with piezoelectric sensor as a cut surface to track the gestures of the dancer for recognizable sound projection and live electronics has been explored. The intuitive cognition of sound linked to a repertoire of movements of the dancers was chosen in favor to complex tracking, like we will outline below.

Developing a musical instrument, performed by or performing with a dancer, was a further issue. Shifting from a reproduction in sound to a transcription instrument for piano a logical step. This was possible since the Autoklavierspieler[3], which are robot piano players, has been developed and enhanced for extreme performances, like “making pianos talk” within Ablingers composition series of Quadraturen[4].

All of this resulted in a machine unit, which can be used as an instrument for dancer, where 12 of them has been implemented in a network for the music-theater “Maschinenhalle #1” as an opening performance for the styrian autumn 2010 [5]. In the following the sound-plate as an interface for robotic piano players is being discussed and the usage within a automated composition is shown.

2. Piece development process

In the recapitulation, why this system has been chosen, some important milestones in the accruement from these development will be shown, extracting the relevant ideas behind the exploration.

2.1 Visualization of musical processes with live video

Within the piece DW6b from Bernhard Lang developed 2001,

figure 2: DW6b Violin, virtual violin

extending a “audio-loopgenerator”[1] with an visualization engine of the loop process in the computer introduced the “visual-loopgenerator”. The reproduction of loops on an video screen behind the performer as a kind of plain visual copy, introduced a virtual player. With the idea, visualizing the processes which

[1] A dedicated software for the loop aesthetics of Bernhard Lang's compositions serie “difference and repetition”.

take place in the computer as audio-processing, enabled a much complexer usage of this algorithms without loosing the perspective of perception as a primer goal.

As an side-effect, adding the virtual player also added another layer to the solo piece and lead to further thinking about the usage of live-video and his reproduction of the live situation, Introducing this copy established a kind of symmetry, which can be understood as a doubling process or mirror or as a virtual musician, which is also a kind of repetition in the sense of Lang's aesthetic. This further emphases by synchronizing audio and video of the computed action, remembering an gesture and its linked sound.

2.2 Projection of a virtual dancer

This inspired us to use a dancer as input for the visual loopgenerator, using the movements reflecting on the sound

figure 3: dancer soundplate with virtual dancer

processing of the loop aesthetics in dance. Here Christine Gaigg came in, with her straight ideas of a choreography developed with Veronica Zott as dancer, where movements are segmented in smaller parts, micro-movements, and reassembled in a kind of slightly varying and shifting repetitions. Using the visual loopgenerator with this micro-movements resulted in one or more virtual dancers performing with the real one, like outlined above. Here the options of doubling live, mirroring the live dance, playing recorded loops of them even using reversed loops added new possibilities to the choreography. Here the size of the time slices are inportant and it showed up that they should not exceed seven seconds to be recognized as repetition.

2.3 Gravity as a major interaction for dancer

To produce, or more likely expressed, to compose the sound for these pieces, triggered a bunch of experiments with different interaction systems: Trying tracking the dancer with infrared tracking systems, using several coordinates of the body out if this information and synthesizing sound and also using sensors like microphones on body and clothing and the sound of the breath lead to additional content. Here we discovered that this sounds because not been originated by the setting and even worse was restricting movements in favor to the sound output lead to a unprecise reception. So the link between dancer and virtual dancers was to complex to be grasped by the recipient and this was a kind of counterproductive for the clearness of this pieces. Since the choreographic idea was important this restrictions on the dance was not acceptable and we searched for much straighter solution and found it with looking at major attractors of dancer, the gravity.

One of this key ideas has been that natural gravity is always present and interacting with the dancer. This trivial discovery came out to be a main aspect in the search for the interface for the transcription. Even if dancer will overcome gravity, he or she have to touch the ground in some way. So we used the floor as a cut surface for the interface. Measuring the contact of dancers with their dance floor was the showed up as intuitiv and logical solution. For this we used an metal plate like a big touch-pad, where piezoelectric-microphones as sensors at the corners of the plate pick up the sound. Processing these signals, the position and strength of the touching has been extracted as time functions.

This worked accurate enough and it showed up, it was easy for dancers to learn to control the interface. As we recognized, if they use the sound of the plate as an feedback, they can train their gestures and movements rembering the sound, so we amplified it and played it back over speakers.

Also we decided that is is much more plausible for the receptor to hear this sound of the real and virtual dancer also for the audience, so it is easier to receipt the structure and processing of piece, allowing us more complex movements and better details. Besides we lworked a on the sound of the plates, so different plates sounds different and also better equalized. This lead to the series of works: VTrike, Trike33, Skizze and NetTrike as pieces for audio and visual loopgenerator [1][2].

Another aspect, the restriction of the active area on the sound-plate came up. It showed that sizes has to fit the size of humans. Taking to big plates did not enhance the choreography very much and also made the sound and reaction more arbitrary. Using smaller ones restricted to much the movements and gestures. From lying on a plate or jumping, it showed the measures of 2m x 1m is perfect for average sized dancer.

In this context the sound and therefore the composition became an image of the dancing, extending it and allowing a range from microscopic movements to very big gestures, like jumping and falling, enabling a very wide dynamic of the piece.

2.4 The vision of an opera mechanica

A different issue for the development of this robotic instrument is the overall vision of the “opera mechanica”, which was developed together with Bernhard Lang. The idea of an opera mechanica lead to a completely automated opera performance, automation including the composition process.

„opera mechanica“ refers to Eulers book „opera mechanica and astronomica“, as a collection of principles, but also to the opera as as an art form, in which singers and musicians perform a dramatic work[2]. “mechanica” refers to machine art, the machine aspects of repetitive performance representing the aesthetics of western cultural identity and contemporary music production and re-production. On one side the opera as institution shows itself as a kind of repetition machinery[3], which performs operas repetitive, but also in the sense of Gille Deleuze`s “difference and repetition”, a composer can be seen as machinery producing

[2] Opera in the sense of real traditional opera, not as the structural abstract form

[3] the machine term is used not only in the sense of the theatre machine by Meyerhold at 1900 , but also abstract like in “Mille Plateaux” by Gille Deleuze

his special kind of artwork. The play with this inspiration was a motor of development of this vision.

One of the first approaches was the piece *"Maschinenhalle #1"* a commission of the Styrian Art festival as opening piece in an old factory hall reconstructed as the concert hall "Listhalle".

So we see machine units with worker as part of a big machinery producing an art work. As this we referred to one of the first accepted mechanical instruments in history, which has been recpeted also as machine, the piano.

This lead us to use instead of the projection of virtual dancer in previous pieces to a transcription of the dance to a piano to project the movements. The metal plate as a feed, an input interface to work on, a computer doing the transcription and a piano playing the result as a feedback is the machine part.

figure 4: Terpsitone by Leon Theremin

Including the dancer as part of the working unit could be seen as an autonomous system, but it is only a networked unit of 12.

The whole machine consisting of these machine units can be seen as a kind of big automata. This idea of automata is also present in the compositional ideas of Bernhards Lang Monadologien cycle[4]. So programming the automata was the compositional work.

2.5 Projection versus Transcription

One important issue of an instrument is that the virtous playing of the instrument can be learned and trained by the musician, in this case the dancer and that the dancer can produce reproducible output. Therefore the projection of the sound is an important intermediate step for this issue.

The goal of the transcription into piano domain was, unlike on coding recordings in piano domain, that the original domain has not to be recognizable and backwards constructable, like this was realized with Peter Ablinger pieces of a talking piano[7]. There the overall algorithm was chosen to be a transcription with the possibility to influence this by a superior machine.

In search of similar instruments we found a first idea from Theremin, first mentioned 1936, the Terpsitone, which measured the body capacity between earth and dancer which was straigthly mapped it to pitch. If you imagine that the dancer has to stoop to lower the tone it was not very intuitive and it was hardly playable[5].

In the following the description of this process will be shon with explaining the instrument with the "sound plate" as interface.

3. The Instrument

The instrument building was inspired more on the development described above, than on other instruments. Historical seen many implementations of dancing interfaces has been realized using sensors and tracking systems of various kinds, but none of them was used as a base since, the development came from another direction, than primarly tracking,

This instrument is realized as an autonomous unit, called machine unit in further reading, including as a control the transcription engine as software. The instrument should act without of a projection or a main speaker system outside its

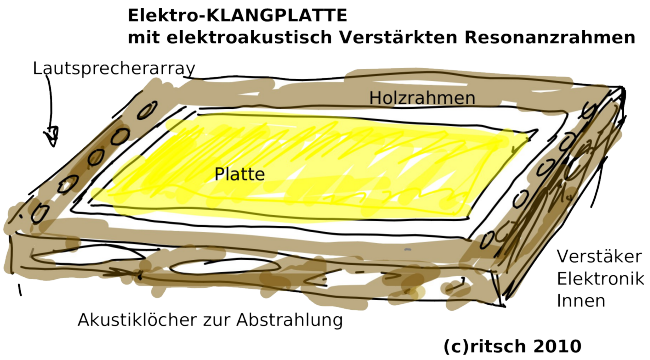

figure 5: draft of the sound-plate

boundaries, so called can be play "unplugged". In the following, the parts of the machine are described.

3.1 "sound plate" with sensors and speaker

Since the brass or iron sound-plate is used primarily for extracting sensor data with pickups at the corners, it should also

figure 6: Siemens Lautsprecher ~1936, algo-speaker 2010

[4] They use state machines, cellular automatas as one compositional algorithms.

[5] "It need hardly be said that there is a great deal of scope for individual talent in coordinating bodily movements so that the sound thus produced will not only fall pleasantly upon the ear, but also combine harmoniously with the preselectd phonograph records. In other words, this is a field of pure artistry."[*Radio Craft*, Dec. 1936, p.365]

be heard by the dancer and the audience to follow the transcription and mix with the piano sound.

Brass tends to be more sensitive and more consise partials in the spectrum of the sounds, iron has more high frequencies and partials and better impulses on tapping. The affiliation of sound and movements on the plate should also be enforced by the spatialization of the sound. With wedges and wood parts, each sound-plate can be adapted with an own imprint of resonances and therefore be distinguished in sound. Trying to equip it with an passive acoustic case, like shown in draft above, was to weak. Amplifying the sound with build in speakers in the wooden acoustic case lead to strong feedbacks, sounding nice, but has also been not usable for this purpose. So an external speaker was developed which reflects not only visually the plate but also can compete with a piano, having a same strength and radiation like it. High frequencies should be heard especially

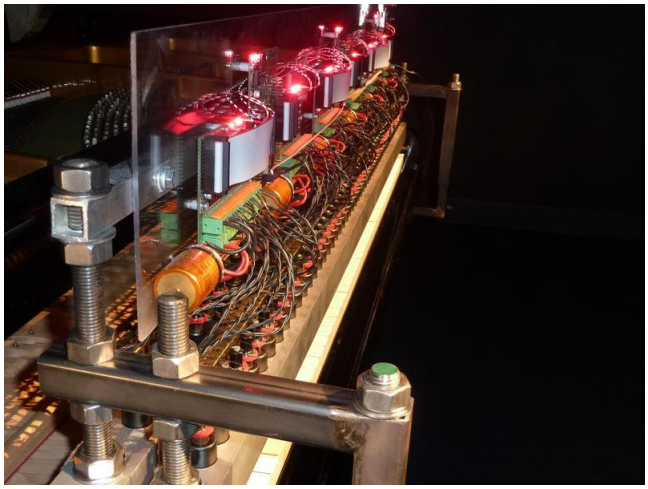

figure 7: Rhea robotic piano player

enforcing transition sounds for better reception of gestures on the sound plate.

As a catalog of characteristic sounds has been made which are: tipping, scratching, sliding, dump hit, etc. This sounds also has been used as a base catalog a transcription engine must distinguish.

3.2 Robot Piano Player

A massive frame with 88 electromechanical finger, which are moved by solenoids, is mounted on the keyboard of a piano. Controlled by micro-controllers, which are driven over a dedicated computer, this “Autoklavierspieler” can be controlled over Ethernet network, files and real time generated music. This robot player has been constructed for extreme performances going beyond human possibilities and beyond common player-pianos on the market. I can play all keys in parallel with individual velocity and up to 50 ms repetition rate each, with a force up to 3kg each, controlled over Ethernet.

The feature of these let play not only tonal melodies, but also clusters and dense parts, which became a kind of spectral representation of the plate sound, as also fast repetitions, accellerations and and cresendos. There is the possibility to play not only the direct ignal, but also virtual ones as overlay.

They have been construted especially for the Maschinenhalle#1 performance. Explaining the needed technical details, would go beyond the scope of this writing.

3.3 Computer control

The dedicated control computer does the transcription locally, interfaced by the audio input from the sound-plates and also being remotely controlled over Ethernet via the OSC-Protocoll. It also controls the conducting monitor and streams a live-cam to the control host, so that it can be conducted remotely by an operator.

It also could be controlled and programmed remotely, not needing any interaction with computer on side using a netboot technoligy and a realtime linux system. This was essential for constructing the control center, where the composers controlled the performance from distance with another control computer and video monitoring of the dancers, like in a observation station.

3.4 Transcription

A lot of experiments has been made to come to a plausible transcription algorithm. Unlike mappings, where from the result

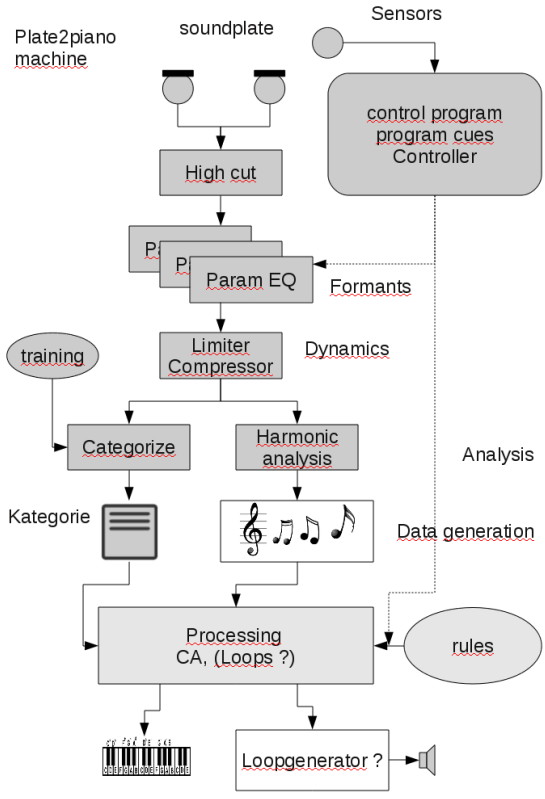

figure 8: transcription process

the originating sound has to be associated here a translation of the input audio signals has be done. It was important that this is a homomorphic imaging of gestures, so that the dancer can always produce quite the same piano playing with same movements at a certain paramter state.

After cleaning and normalizing the input signal, sound has to be categorized in slides, trappings, bumps and rubbing and for each category a algorithm and mapping has to be found. Therefore FFT-Analysis was used in paralell to constant-Q and wavelet-analysis. Additional onset detections with transient analysis was done. Since sound plates tends to have concrete partials for each resonances on different positions and the plates were prepared that local movement of contact on the plates can generate glissandi, also note follower algorithm for this had to be implemented.

But most of the problems had been solved in the note domain, after extracting the core features of the output. After all the process, a very specialized, adapted to the composition transcription engine has been evolved, incorporating and representing major part of the composition art work.

A second stage for applying harmonics filter and beat filter was essential to be able to play the instrument from a composers view and inventing additional parameters to change the sound produced by the pianos.

All this lead to a big parameter space and possibilities, at last 110 parameters for each scene to be adjusted. Two thirds of them are individual to each instrument place, the other can be controlled globally.

3.5 Conducting Monitor

Controlling the dancers of the machine unit and synchronising them with other units a conduction technique has to be found.

The dancer has a sound feedback from the plate speaker and the piano to integrate in the machine unit. To synchronize the machine units an additional modality has to be introduced, mainly targeting the dancer. Since click-tracks or audio signals interfered with the sound played, after a lot of unsuccessful attempts with counters, we found that a click-watch has been the best solution. This is a combination of a clock with a pointer, which rotates within phrases, flashing at beginning and counting down the phrases within a scene. Also the active and inactive pahses are shown with araes of different color. The visualization has to be intuitive and also recognizable not always concentrating on the screen, like light signals do.

This gave the dancer the freedom in his position movements and a visual rythmn more appropriate for dancers, since they mostly not trained musician, which can read scores.

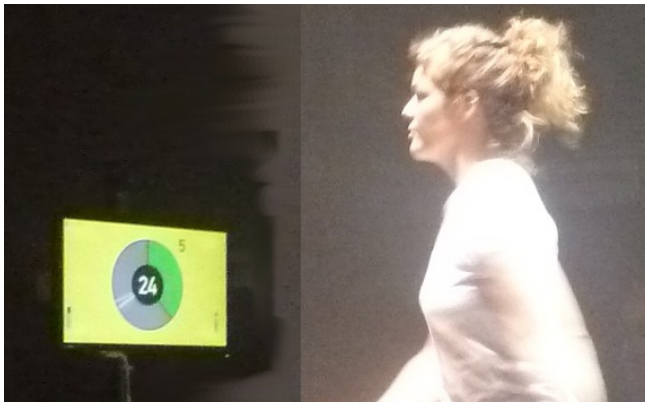

figure 9: conducting monitor as visual interface

3.6 Movements and Calibration

With all of this feedbacks and monitoring, the dancer is able to learn the instrument and that each movement on different positions will produce always quite the same reaction.

Since weight and agility of dancers vary, as also the plates do, the whole instrument has to be calibrated for the dancer and the personal sound-plate. This unity has to be learned and maintained by the dancer, doing excercises.

This gives the choreographer in cooperation with the composer the possibility to work with a catalog of movements and therfore sounds and piano phrases to construct the piece as composition.

3.7 Machine unit

All of these parts forms a machine unit, which can be used isolated as instrument also in other contexts like ensembles or solo performances. To control the machine unit a OSC-protocol was established, so a master controller can influence live all the essential parameters.

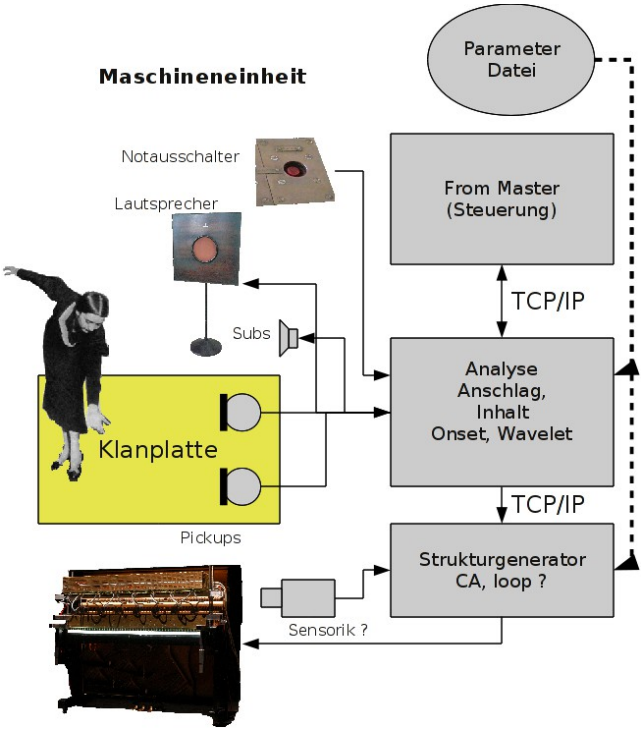

figure 10: machine unit diagram

As we see in the diagram of the machine unit this forms a new instrument including the dancer as part.

4. The performance

In the performance, 12 of this machines units has been connected over network over a 1GBit-Ethernet, being controlled by a master station in one front of the room. Since the machine units has been distributed through-all the 800m2 concert room and the audience could walk in this room very near to the units and between them, it was necessary to observe them trhough video cams on top of the control monitors.

At the control table the harmonics filters and dynamics of the machine units has been controlled in a live mix to react on the behavior of the audience and dancer.

For this special instance of the performance at the list halle, also podest has been used, so dancers had an additional border of

figure 11: control table at performance

3mx2m, where they were placed. The pedestals has been chosen to be 40cm height, so on one side the link to table dance was prohibited on the other they could be seen by more people.
After recapitulation of this performance, the instrument has been proven to work and being a reusable in other artworks.

5. ACKNOWLEDGMENTS

Thanks for the IEM to let us do the studies and Atelier Algorythmics for building the machine units and doing a lot of research. Also for team of the Maschinenhalle#1 production especially Christine Gaigg and Bernhard Lang for the intensive work during the artistic research. Here the complete team:

concept and artwork: Christine Gaigg, Bernhard Lang, Winfried Ritsch and Philipp Harnoncourt; Assistent: Iris Raffetseder; Dancer: Quim Bigas Bassart, Sara Canini, Ella Clarke, Alexander Deutinger, Christine Gaigg, Robert Jackson, Milla Koistinen, Anna Majder, Asher O'Gorman, Eva-Maria Schaller, Magi Serra Foraste & Veronika Zott
Maschinists and network: Peter Innerhofer, Mario Kafka, Michael Klamminger, Matthias Kronlachner, Mauritio Nielson

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figure 12: Maschinenhalle performance, left side