NEW TENDENCIES IN THE DIGITAL MUSIC INSTRUMENT DESIGN : PROGRESS REPORT

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ABSTRACT

This paper is a progress report from a workgroup of the University of Music Karlsruhe studying Music Technology at the *Institut für Musikwissenschaft und Musikinformatik* (Institute for Musicology and Music Technology). The group activity is focused on the development and design of computer-controlled instruments – digital music instruments [5].
We will describe three digital music instruments, havedeveloped at the *Computer Studio*. These instruments are mostly unified by the idea of human gesture and human interaction using new technologies to control the interaction processes. At the same time they were built upon the consciousness of musical tradition taking a fresh approach on everyday objects.

1. META_SONIC.IN PLACE

meta_sonic.in place is an interactive sound installation in which sounds can be triggered by color recognition. The aim of the work is to create a new, heightened experience of sound and space [10]. This installation was first used in the courtyard at Wedinghausen Monastery (www.kloster-wedinghausen.de) as part of the 12th *Internationaler Kunstsommer Arnsberg* (Arnsberg International Summer of Art - [www.kunstsommer-arnsberg.de].

Figure 1. picture of the opening[1]

Visitors are able to interact and influence the sounds directly; they can decide on how to combine the sound material and can change its characteristics. They do this by using either a colored scarf or a glow stick as they walk around the courtyard, exploring and discovering what the place has to reveal (Fig. 2).
meta_sonic.in place is structured in two levels : a hardware and a software level. The hardware part consists of a PA (5 loudspeakers, subwoofer, mixer), which provides for the acoustic irradiation, an audio interface, a MacBook Pro and a camera. The camera detects the movement of the visitors as part of the interaction process. The software level is a standalone application developed in Max/Msp and Jitter [7]. With the software application we can manage the sound material and control the live electronic sound processing.

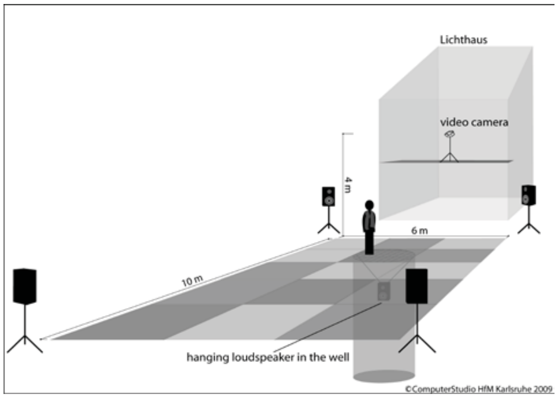

Figure 2. schema of the realization in the courtyard at Wedinghausen Monastery

[1] - Picture by Julian Stratenschulte

1.1. Interaction Process

In the monastery courtyard, there was a raster comprising 15 fields (Fig.3), defined by the given structure of the venue. Nine of these were active at one time. The order of the fields changed every 30 minutes (inside of the application) as predefined rule. In addition, audio effects could be triggered in four of the nine active fields. Three central fields, one of which was the over the shaft of the former courtyard well, were always active.
It is also possible to use a different number of fields and a different raster. The key factor is that the user is provided with a matrix, which is easily accessible.

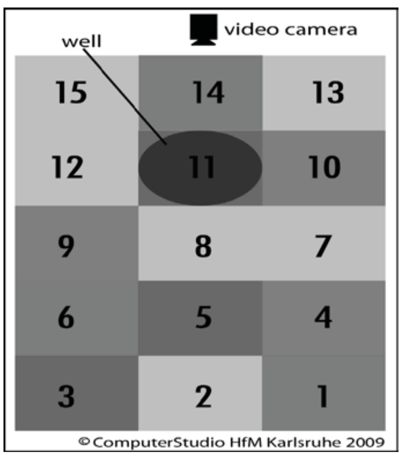

Figure 3. instance of possible array of fields

1.2. Color Recognition

The location is surveyed by a camera positioned several meters above the area. The video frame is then divided into different fields, which are programmed to detect different colors. A color filter programmed into Jitter reads the video signal and identifies the colors red, blue and green in defined image sections (fields). If one of the defined colors is filtered in the image section, a sound is activated or an existing sound is modified.

1.3. Audio

The sound library establishes a connection between the past and the present of the place where the installation is applied. Around 100 samples in stereo and mono were produced for the installation at Wedinghausen Monastery, including religious music, which had been changed to unfamiliar sound, ambient noises and synthetically generated sounds. One of the most important objectives in this work consists on the spatial and historical integration between the real space and the sound art object – the installation.
Various stereo pairs could be created using four loud speakers. So the spatialization was effected by using a combination of individual loud speakers, while the fifth loud speaker in the well only played back mono sound files. Each field was assigned nine sounds chosen for compositional reasons, which were played back in a predefined order. Once a sound was activated, it could be modified in four different ways:

- ***drunK71:*** *which consists of the effects pitch and stereo-delay. Short delay-times (ca. 200ms) give the pitched sound different nuances.*
- ***FREQdelay:*** *comprises two different effects that work independently of each other: by random-process, either a down and upward glissando or a stereo-delay is applied. The signal thus produced is played parallel to the original: if the original signal comes from one side, the modified sound is heard from the other side.*
- ***ALLout:*** *is an effect especially for the field above the well. If a color is identified here, the sample triggered comes to the fore while the outer loudspeakers are muted.*
- ***MONroom:*** *like ALLout, it is especially designed for the "well field". If this effect is activated, the signal is also routed to the outer loudspeakers.*

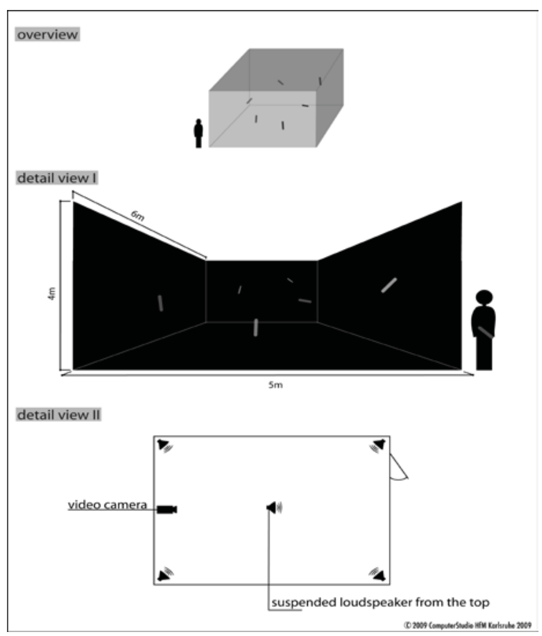

Figure 4. Possible indoor realization

1.4. Results

The concept aims to create an installation which is as ambivalent as it possibly can be, the core of which is like an instrument which sounds different depending on where

and by whom it is played, but which is always played in a similar way. The sound material, the spatialization and the type of effects can be adjusted to fit each individual location where the installation is applied. However, the visitor should always take on the role of interpreter [2] in addition to his or her classic function as listener.
The scene created in Wedinghausen transformed the monastery courtyard into a stage with the old well as its center. As this was the first location where the concept was realized, the well became the inspiration for the title *meta_sonic.in place*. The project is named after the Ancient Roman Meta Sudans, a fountain with a conical 'meta' in its center, a construction, which also marked the place where racing chariots would turn in a Roman circus.

2. CYCLEONIUM

The *cycleonium* is a computer based music instrument [5][8]. Every day objects like a bicycle and a bottle, and also a propeller are put in a new context and form the base of the sound design. They lose their conventional function consequently and have to be considered as indispensable parameters of this instrument. The physical and mechanical work that is required to make this sound-machine sound basically doesn't differ from traditional musical instruments. For instance, a guitar: it sounds, respectively do we perceive it acoustically, if the strings are excited or the corpus is oscillated somehow or other. So the player expends energy and translates it into the instrument. The user and viewer of the *cycleonium* is to be made aware of that, in principle, musical instruments are nothing else than objects that only operate with a certain energy expenditure. The energy flow that is emerged thereby plays here a primary role. Therefore we use the word fluxus, but more in a semantically significance (lat. flux, fluidum = flow) than artistic aesthetics [4]. Any kind of sounds require energy to sound. They have self-energy indeed, but it first has to be excited. Otherwise every sound is only a sounding abstraction (they aren't a perpetual motion machine) . The player of the *cycleonium* produces, amongst others, kinetic energy that excites a propeller that simultaneously blows air on the aperture of a bottle: a pitched sound is audible.

2.1. Description

The *cycleonium* consists basically of four pieces: a bicycle (Fig. 5 and Fig. 6), a bottle and a propeller that form the hardware and a computer for software-based sound processing (live-electronics).
The bicycle is rebuilt in such a way that it resembles a stationary bicycle. In this way the propeller can be powered whereby the emerging air flow hits the angle of the aperture of the bottle. Likewise in a flute, a periodical oscillating air column that is perceivable as a tone pitch is produced in the corpus of the bottle [1]. The intensity of the sound depends on the speed of the propeller and consequently on the expended force of the player. The blades of the propeller are fixed up in a way that they turn down and cause a rattling noise if the speed is too low. Thus the interplay of the expended force of the player with the speed of the propeller and thereby with the sound of the bottle is directly audible and explicit. The breath of the player and the sound of the chain and arbor of the bicycle are as equally important as the sound of the bottle itself. The produced sounds are amplified and real-time processed.
The live-electronics take place in Max/Msp [7] on a Laptop. The sounds can be pitched, transposed, filtered, recorded and played and processed with delay or reverb. Each Parameter can be controlled with a MIDI-controller. The following microphones are used:

bottle:	*electret microphone*
breath:	*dynamic microphone*
chain/arbor:	*condenser microphone (cardioid)*

For instance, over the keynote of the bottle can be formed an overtone scale with 15 partials or more that are controllable individually. The spatialization is realized with delays, which can be filtered, pitched and assigned to the respective audio-outputs discretely in real-time [3]. To bring the bottle in the best possible position to the airflow one can adjust it in height, distance and angle to the propeller.
The *cycleonium* was built with the support of the apprenticeship workshop of Chiron-Werke GmbH & Co. KG (www.chiron.de).

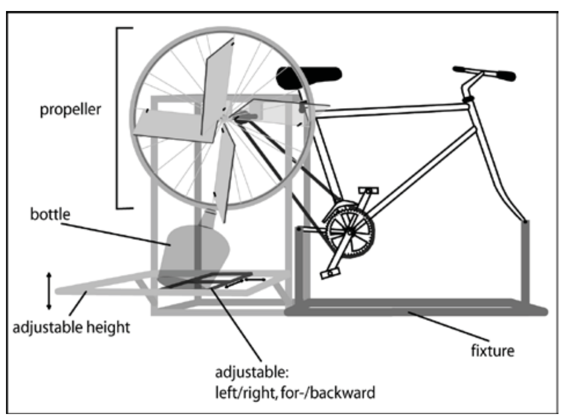

Figure 5. Technical schema

2.2. Purpose

The player perches on it like on a stationary bicycle and starts to pedal. The midi-controller and the Laptop can be put on a tray that is at the height of the handlebar. By using a dynamic microphone that is at the height of the mouth he can experiment with his voice respectively breath and modify it per MIDI in real-time. The sound of the arbor at the propeller and the chain is recorded with a condenser microphone (cardioid). Through reverse turns of the pedals the sound of chain and arbor becomes more concisely and is at the same time a variation of sound. By alternating forward and reverse turns a percussive rhythmical complement is built to the laminary sound of the bottle that mainly can be modified in the pitch. Dense and complex structures of sound can be achieved by adding overtones, glissandi and delays.
With this prototype of the *cycleonium* a performance was realized at the Kubus of the ZKM in 2009.

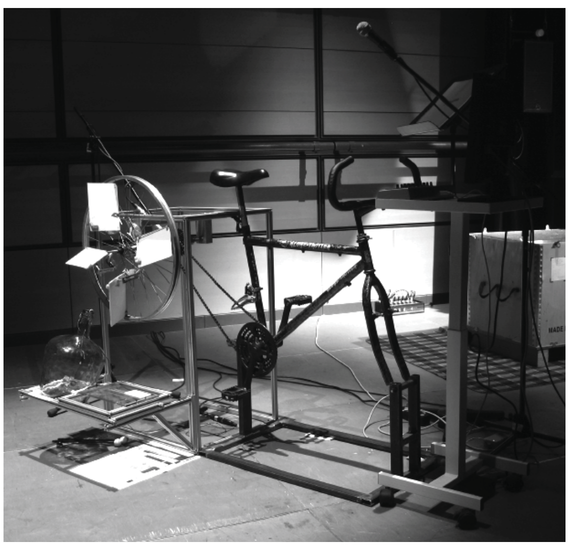

Figure 6. picture of the *cycleonium*[1]

3. PULSE GUITAR

3.1. Introduction

The *PulseGuitar* is a digital musical instrument [5]. It combines an electric guitar with a computer-controlled interface. While the strings of a conventional guitar are to be plucked by the player's fretting hand, the strings of the *PulseGuitar* are excited by micro loudspeakers (voice coils) that are attached near them (Fig. 7). The force transmission is mechanical. The instrument is played by moving a joystick which is fixed on its body with one hand, and, as usual, fretting the notes with the other hand.

[1] Picture by Kai Hanneken, ZKM 2009

The data from the joystick controls a software synthesizer whose signal is amplified and finally routed to the voice coils. Dependent on the deflection of the joystick a program decides which coil the signal is routed to. The *PulseGuitar* can produce other timbres and rhythmic gestures than a common electric guitar.

Virtual Musical Instruments are based on modules. We can clearly separate the controller module from how the sound was produced (sound module). In this context, the instrument is controlled by sending data, such as MIDI, to some synthesizer or sampler that outputs sound [6]. At the very most, traditional acoustic/electric/electro-mechanical instruments do not fit into the scheme of modularity.
Since the electric guitar is an electric instrument, the controller and the sounding part cannot be separated into two independent components. The strings represent the controller module and also the origin of the sound and the major part of the sound module at the same time.
Changing any part of the controller would also affect the timbre of the instrument whereas replacing the controller of a virtual instrument will not cause any impact on the sound module.
The *PulseGuitar* revisits the electric guitar and takes a new approach in terms of how to play/control it.
It is fair to mention that several tools which aim to widen the musical diversity of the electric guitar have been developed in the past. Prominent devices are the Ebow (www.e-bow.com) and also the *Moog Guitar* (www.moogmusic.com/moogguitar). Both work, unlike the *PulseGuitar*, with electromagnetic fields that affect the state of the strings.
The PulseGuitar stays with the idea of plucking strings mechanically but expands the possibilities by passing the task to a machine.

3.2. Experimental Procedures

The synthesizer was built in the Max/MSP 5 programming environment [7]. It only produces a sawtooth wave, which is variable in frequency domain. Its signal is routed to little voice coils that are attached on the body of the guitar near the strings. Each string is equipped with its own voice coil. The mechanical movements of the coils are transferred to the strings. It is crucial to understand that the oscillator is not used as a musical instrument. Rather the physical deflection of the voice coils is needed. The strings are not plucked but hit.

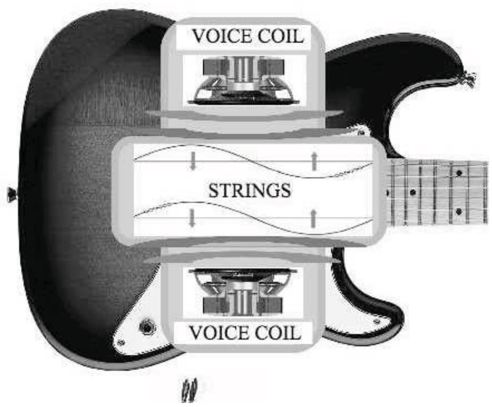

Figure 7. Schematic illustration

As a result, the synthesizer controls both the excitation of the strings and takes over the task of the player's right hand.

The synthesizer is controlled by a joystick (Fig. 8), which is also attached to the body. Turning the joystick up and down, the string to be played is selected, moving the stick sideways defines the frequency of the oscillator (Of course, other controllers such as a touchpad could be used). The range of the frequency is variable from 0.5 Hz up to 200 Hz so the strings can be hit 0.5 to 200 times per second.

In the end, the vibrations of the strings are captured by conventional pickups.

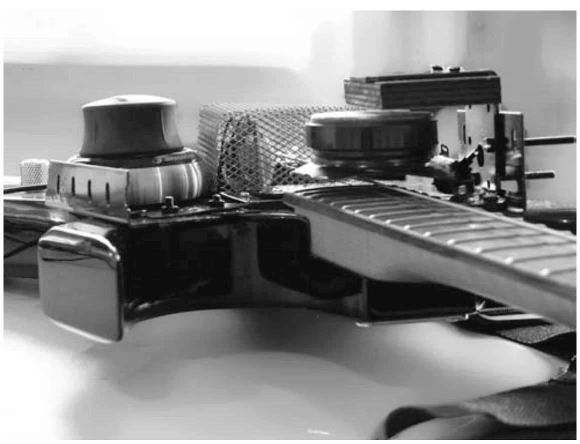

Figure 8. Picture of the *PulseGuitar*

At the moment, the *PulseGuitar* supports only two strings because a two channel audio interface was used. However, the string number can be easily increased using a multi channel interface.

The sound of the instrument depends on the frequency of the oscillator (and of course on the amplifier). Below about 20 Hz the otherwise continuous perception of oscillations (tone) changes to a perception of single events (rhythm). So if the strings are being plucked between 0.5 to 20 times per second the sound resembles a common electric guitar because a guitarist can't help playing in that time domain due to motoric limitations. If the frequency is increased though, it becomes more interesting. Above 20 Hz single excitations are not perceived as single events anymore, they unite with the sound of the strings.

The interesting part is not the fact that with the *PulseGuitar* one can play really fast (even though you could if you wanted to). Rather the timbre is interesting. It is percussive and harmonic in equal shares. The first live presentation of the *PulseGuitar* was done January 21, 2009 at ZKM Karlsruhe January 27, 2009 at Centro Cultural Belem Lisbon with the Portuguese Contemporary Music Ensemble OrchestrUtopica.

4. ACKNOWLEDGMENTS

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