Homo Restis - Constructive Control Through Modular String Topologies

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ABSTRACT

In this paper we discuss a modular instrument system for musical expression consisting of multiple devices using string detection, sound synthesis and wireless communication. The design of the system allows for different physical arrangements, which we define as topologies.

In particular we will explain our concept and requirements, the system architecture including custom magnetic string sensors and our network communication and discuss its use in the performance *HOMO RESTIS*.

Author Keywords

NIME, performance, composition, generated audio, wireless instruments, strings, latency

ACM Classification

C.0 [General] Hardware/software interface, C.2.1 [Network Architecture and Design] Wireless communication C.3 [ARTS AND HUMANITIES] Performing arts (e.g., dance, music) C.5.3 [Microcomputers] Portable devices, H.5.2 [User Interfaces] Input devices and strategies, H.5.5 [Information Interfaces and Presentation] Sound and Music Computing.

1. INTRODUCTION

The attempt to push boundaries of traditional models of interfacing with instruments and the extensive interest in new topologies for sound creation not only applies to interactive, modular or digital instruments in general, but also to body-related instruments in particular. Requirements like mobility, real-time interaction, tactile qualities or stable network synchronization still demonstrates the need for experimentation and research.

In order to create custom modular and wireless instruments for our performance project *HOMO RESTIS* we started to explore new possibilities for mobile sound-generation, mobile multichannel audio and stable network communication.

2. RELATED DESIGN ASPECTS

In the past decade new body-related instruments evolved as a form of sound and data interaction interfaces, were made possible through affordable electronics, programming and often also wireless communication. Known projects in this field amongst others are The Gloves Project [5], BioMuse by Atau Tanaka or upcoming projects like e.g. Glissando by Ulla Rauter[1]. Some of them are working with mechanical or bioelectrical input, others are working with physical conditions like gravitation, speed, humidity, etc.

The above examples have encouraged us to develop our own tools, based on our requirements.

2.1 General Interface Design

Accompanying new forms of interactive instruments one has to take particular needs into consideration in order to embed the instruments into live performances or concerts. They could be summarized as followed:

(1) **Precision.** Instruments should be as precise as possible to stimulate virtuosity in musical performances.

(2) **Understandability.** As sometimes Developer and Performer are not the same persons and the Performer does not necessarily know all functions or issues of the new instrument, those instruments need to be intuitive in functionality and handling.

(3) **Robustness.** Performances and concerts are often fast and impulsive. The instrument needs to be robust and stage-proof, despite the fact of using micro-computer and fragile sensors.

Figure 1: Homo Restis Costumes

2.2 Strings as Instruments

In our development process, we first began to test weight sensors and mechanical springs until, for practical reasons, we encountered the possibility of using ropes or strings.

There are examples of the use of strings as musical interfaces, such as the group *JUNG IN JUNG* with their piece

[1] see http://ullarauter.com/content_Glissando.html

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Thermospheric Station [1]. They used the Gametrak[2], a 3-dimensional game control system based on position tracking. The Gametrak is an example for decoupling strings from their traditional acoustic use (e.g. in instruments like Harp, Piano, etc.) in order to allow more interaction models than just plucking or brushing.

But unlike Gametrak, we needed stronger and, above all, longer strings for our intention to use the interfaces in the public space.

2.3 Modular Topologies

While classical instruments mostly are prefabricated, new instruments can be developed according to the needs of the performer or artists. Today the creation of the instruments is connected to performance aspects, musical improvisation is embedded in the physical or functional form of the instrument. A new flexible modularity is entering the process of sound creation and performance [2], especially by combining the use of electronic devices and digital processing. While traditional instruments had fixed architectures (e.g. parallel strings in Pianos), new modular interfaces can augment them [4] or even build up different topologies (e.g. mesh, star). Combining those new topologies with real-time interaction, the performer can enhance his musical improvisation by flexible routing and modular reconfiguration of the instrument.

Figure 2: Homo Restis at Kunstzug

3. HOMO RESTIS

HOMO RESTIS (see Figure 1 and 2) is our recent performance project and includes handcrafted costumes designed by Sarah Leimcke and the mobile modular instrument system developed for the use in public spaces by Jens Vetter. Sound devices and costumes were developed side by side, as we had to embed all technical requirements inside the costumes and vice versa.

3.1 Concept and Vision

The starting point of our performance was the idea of Marionettes, that we understand as a metaphor for human-beings trapped in the complexity and opacity of modern live and society. We wanted to create a public representation through the aesthetic and sonic presence of the *HOMO RESTIS* (lat. "Men on Strings").

While our first concept was a body-bondage arrangement, that would seek to constrain body movement with rubber strings attached (similiar e.g. "Muscular Interactions" by Marco Donnarumma [3]), in the end the weight of the costumes made our decisions. We changed the concept from attaching strings only between our bodies to attaching strings from our bodies to the environment.

Our main requirements were **(1)mobility** - being independent from power supplies, but also from technical support such as PA Systems, Surround Sound Systems etc. **(2)loudness** - mobile devices at minimal weight should produce enough loudness to fill public spaces, **(3)modularity** - multiple devices in order to arrange performance-situations in a flexible and modular manner and to achieve multichannel audio across bigger spaces, **(4)long strings** - enlarging the radius of our performance in order to fill larger environments, especially public spaces like squares, streets or tunnels.

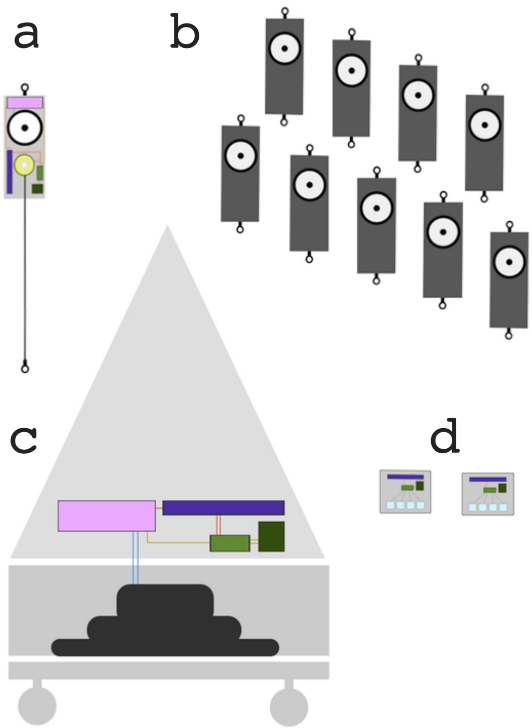

Figure 3: Devices - a) Soundmodule interior - b) Soundmodules - c) Subwoofer - d) Costume Controller

Our goal was to enter public places in our costumes, to then place the soundmodules performatively in favorable places in the environment and to attach our bodies with long strings to them. Through gesture and movement we would produce and control sounds. With the help of the remotes in our costumes, we could change sound presets or

[2]see `http://en.wikipedia.org/wiki/Gametrak`

mute the sound.

Some particular needs became clear immediately: we needed battery-powered devices and lightweight constructions for mobility. Regarding loudness we needed a subwoofer to generate low-end frequencies that would increase the level of loudness. We needed wireless communication between all devices to achieve modularity and flexibility and to be able to control and modulate the sound-generation process remotely.

3.2 System Architecture

The development of the entire system resulted in several dedicated devices and a complex programming for the use as wireless sound system. We embedded string-controller, sound synthesis for generative audio, different Output-Modules including a subwoofer, audio and network protocols for real-time sound-creation and enabled parallel communication between groups of devices.

Regarding audio synthesis we embedded different sound presets, that we could access remotely during the performance, as well as general volume dimming.

During the development process we had to accomplish extensive research on how to create robust string sensors, how to organize battery-driven electronics including speaker and amplifier in single lightweight devices and how to embed all the wireless functionality without data-losses.

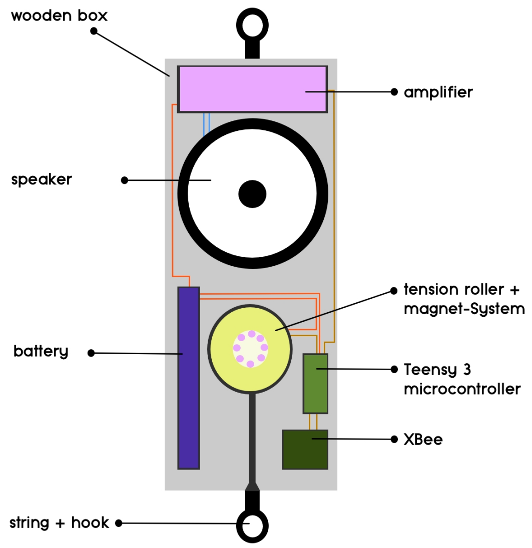

Figure 4: Soundmodule parts

3.2.1 Devices

The system consists of 10 independent battery-driven soundmodules, that provide each a string of 8 meter, a speaker plus amplifier, a Teensy 3 Board[3] as micro-controller for sound creation and a wireless access-point using XBee[4]. Additionally we build a mobile subwoofer-box, including a 400 Watt speaker and amplifier and a wireless access-point with 10 complementary micro-controllers for sound generation of the low-end frequencies.

Finally we built two controller modules, sewn into the costumes, that would allow us to access the system in terms of choosing sound presets, dimming the overall volume or manipulating active sounds (see Figure 3 and Figure 4).

3.2.2 Electronics and Magnetic String Encoder

A challenging task was the development of an appropriate string sensor. While in the beginning we experimented with conductive rubber tube sensors[5] we experienced, that none of the simple stretch sensors would achieve our desired results. After equally unsatisfying mechanical approaches (e.g. transmitting the movement of strings onto potentiometers) we started to focus on magnetic encoder mechanisms, which was the key to create robust string sensors.

Our custom magnetic string encoder is based on Hall Effect Sensors[6] and a tension roller. Magnets are attached to the tension roller and as the roller spins, magnetic sensors on the outside of the tension roller detect changes in the magnetic field. With a minimum of two magnetic sensors per tension roller we were able to calculate und use **1) speed** and **2) direction** of the spinning. In order to guarantee stable circuits we chose to produce custom circuits using Fritzing[7].

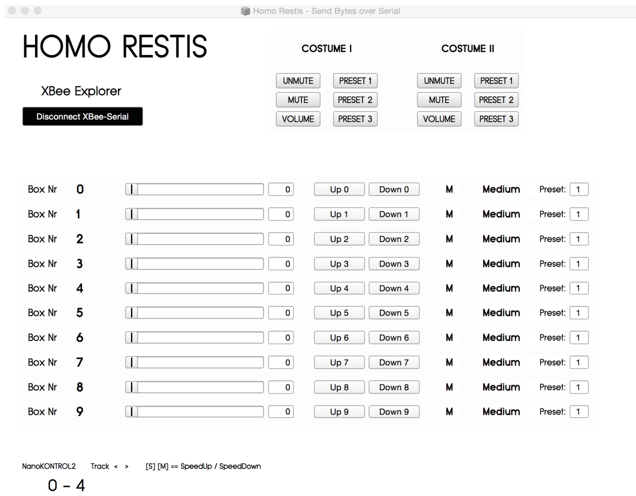

Figure 5: Screenshot SuperCollider

3.2.3 Wireless Network and Sound

The programming and networking in all devices is realized using Teensy Boards and XBee modules. They communicate over their serial connection. In order to create a modular system of sound devices that would permit both flexibility during performance and loudness, we decided to connect a subwoofer wirelessly to the single sound devices. This allows distribution of sound output across multiple devices, which means that we are able to keep the single sound devices at small sizes, whereas the subwoofer is the only really big and heavy device.

Our way to realize this sound architecture was to embed a dedicated arrangement of separate micro-controllers inside a separate subwoofer-module next to the subwoofer. The subwoofer-module mirrors processes of each single soundmodule, so that whenever a soundmodule is played, all calculations are wirelessly triggered both in the single device and in the subwoofer-modules complementary micro-controller.

[3] see `http://www.pjrc.com`.
[4] see `https://www.digi.com/lp/xbee`

[5] `http://www.adafruit.com/product/519`
[6] `http://en.wikipedia.org/wiki/Hall_effect_sensor`
[7] `http://fritzing.org/`

In order to embed the network communication with as little latency as possible we reduced the bandwidth to 8 bits or 256 patterns that we used to encode activity.

Incoming string-sensor-messages generated following reduced output-informations: a message for (1) string moved one step forwards, (2) string moved one step backwards, (3) choose 1 from 3 sound presets, (4) dim the volume, (5) reset internal calculations.

According to our observation, limiting wireless interaction to 256 pattern produced higher reliability during transmission. The reliability of the connection, however, depends on the XBee modules used - stronger models bridge longer distances.

A big benefit was the possibility to access all devices directly from the computer and to remotely control them. Also the development of other aspects of the programming could now be done very comfortable without having to physically move the strings and modules[8]. A custom software written in SuperCollider helped to access, monitor and control all devices remotely (see Figure 5).

3.2.4 *Generated Sound*

All sounds are created using the MOZZI sound synthesis library for Arduino[9] and the Teensy's Analog Output. Using MOZZI allowed to generate synthesized sounds, to use prerecorded samples and to embed interactivity (e.g. remotely changing presets etc.). The Teensy's 72 MHz Cortex-M4 processor is a limiting factor.

3.3 Instrument Design

The cases for the soundmodules are made of waterproof plywood. All parts were manufactured by CNC. This was necessary to achieve precisely the same dimensions for every box, as there is not much space to mount all electronic parts inside the case (Figure 6). The subwoofer case serves as a transport space for the individual modules.

Figure 6: Soundmodules

3.4 Performance and Experiences

After completing the development process we attended several festivals in 2016[10], so that now we can confirm by overall performance experience, that the entire system is sufficiently stable and reliable. As previously mentioned in section 2.1 our instruments are close to self-explanatory and robust and also precise in analyzing and transmitting sensor data coming from the strings. The sounds were loud enough to compete with street sounds or other noisy situations. Interacting with the strings was also stable and satisfying.

We were apprehensive, that the battery power would be a limitation, but that didn't happen.

To summarize we were able to perform, move and also maintain the soundmodules in the desired way and as they are a very fundamental part of our performance *HOMO RESTIS* they really completed our appearance and performance in the best possible way.

4. FUTURE DEVELOPMENTS

The production of this modular interactive instrument system as well as the application in a performance context has brought us many insights. The next step in *HOMO RESTIS* will be the improvement of the dramatic embedding of the interaction with the strings and programming new sounds based on the MOZZI library.

Furthermore it is also conceivable to use this system as the basis for interactive exhibitions, in which the active strings may be connected to passive strings or objects.

It could also be interesting to use it as a group interface with dancers, musicians or the public on stage or in public places.

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Also we want to thank all those, who share knowledge and contribute in all those forums in the net - without all of you it would have been significantly harder to develop our project!

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[8] A great help in programming multiple Teensy's was TyQt. `https://github.com/Koromix/teensytools`

[9] see `http://sensorium.github.io/Mozzi/`

[10] e.g. Ars Electronica, Spekulum Artium, Kunstzug, Sonic Lab of Anton Bruckner University