Osiris: a liquid based digital musical instrument

Martín Matus Lerner
Desarrollos tecnológicos digitales aplicados al arte
Escuela Universitaria de Artes - Universidad Nacional de Quilmes
Buenos Aires, Argentina
mmatus@unq.edu.ar

ABSTRACT

This article describes the process of creation of a new digital musical instrument: Osiris. This device is based on the circulation and detection of liquids for the generation of musical notes. Besides the system of liquid distribution, a module that generates MIDI events was designed and built based on the Arduino platform; such module is employed together with a Proteus 2000 sound generator. The programming of the control module as well as the choice of sound-generating module had as their main objective that the instrument should provide an ample variety of sound and musical possibilities, controllable in real time.

Author Keywords

NIME, Digital Musical Instrument, Liquid based sound generation

ACM Classification

H.5.2 [Information Interfaces and Presentation] User Interfaces --- User-centered design; H.5.5 [Information Interfaces and Presentation] Sound and Music Computing.

1. INTRODUCTION

The proposal of this work consists in the design and construction of a digital musical instrument: Osiris. This instrument proposes the generation of sound based on the circulation of water. There are various instruments in existence which have a functioning principle based on liquids, the majority of these being acoustic instruments[1]. This paper proposes a device that is based on the flow of electric current through a liquid medium for the generation of sound and music.

The first experiences involved the use of analogue oscillators, which soon proved to limit the potential of the device. Consequently a new digital version was designed afterwards, building a control module and introducing a more versatile sound generator.

2. INITIAL EXPERIENCES

The process of creation and construction of the first analogue prototype had as premises the use of low-cost electronic technology and to explore the aesthetic possibilities of simple electronic devices. The project started with the construction of several low-tech audio oscillators. The original aim was to build several of these simple oscillators, and to generate interest in terms of sound by means of their combination.

The oscillators were built using the CD40106 CMOS integrated circuit which has six Schmitt Triggers[2]. Two integrated circuits were used for the prototype (thus counting on twelve oscillators[3]), tuned to a fixed scale of pitches by means of presets. The interaction with the liquid is produced at the end of the audio output of each oscillator: the circuit is opened and two conductors are set a few millimeters apart; in contact with the drop of liquid this allows the flow of electric current, permitting the audio signal output[4].

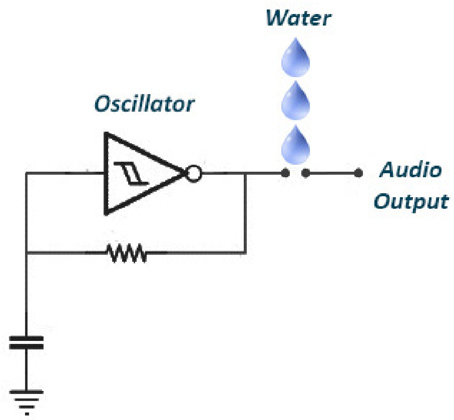

Figure 1. Simplified operating scheme of the first device

For the distribution of liquids a water pump was employed; when activated it distributes the liquid along several hoses. Each of these hoses is provided with a dropper which enables to regulate the flow rate through it, controlling the drip. When a drop falls an audio output closes, corresponding to an oscillator with a specific tuning. The speed of the drip determines a type of rhythm and the combination of the different drips allows for results of a medium degree of complexity.

Even if this first version was very instructive during an experimental and learning stage, several limitations soon became evident. For this reason, a new version of the device was implemented.

3. A DIGITAL MUSICAL INSTRUMENT

3.1 General operating scheme

A new version of the instrument was designed introducing a microcontroller and a more versatile audio generator. For the creation of this digital version of the instrument, a control module was designed based on the Arduino platform, which sends MIDI control

[1] Steve Mann has created several instruments which base the generation of sound on alternative principles to those of classical acoustic instruments. Among them, the Hydraulophone and the Poseidophone are both based on water [1]. Other instruments of interest are the Aquaphones developed by Jacques Dudon [2], and the Waterphone by Richard Waters [3]. All of them are acoustic instruments with the exception of the Poseidophone, which is electroacoustic and can also be used as a MIDI controller.

[2] About Schmitt Trigger circuits, see: [4].

[3] About oscillators based on R-C networks, see: [5] and [6].

[4] Pure or distilled water behaves electrically as an insulator. Water acquires good electrical conduction properties when ionic compounds are added, such as certain minerals.

NIME'17, May 15-19, 2016, Aalborg University Copenhagen, Denmark.

events to a sound-generating module. According to the classification proposed by Miranda and Wanderley, Osiris possesses an alternate controller, since it is “not directly modelled on or necessarily inspired by existing acoustic instruments” [7].

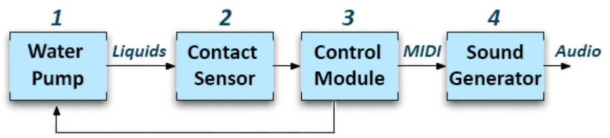

Figure 2. Osiris: general operating scheme

Figure 2 schematizes in terms of modules the several stages that conform the instrument:
1) The water pump (activated by the control module) feeds a series of hoses that make water circulate.
2) Drops resulting from the various hoses spill onto a series of electrical contacts which work as switches activated by the flow of water.
3) The control module generates MIDI events on the basis of the detection of water. The events generated have parameters configurable by the user in real time.
4) The sound-generating module produces audio based on the MIDI data received.

Figure 3. Liquid distribution system

3.2 Liquid distribution system

Various water pumps can be activated in an independent manner by means of Arduino-controlled relays. The pump feeds an independent system of liquid distribution: from each pump a series of hoses branch out, provided with droppers to control the flow of water. The drops resulting from the various hoses spill onto a series of electrical contacts. These contacts are connected to Arduino digital inputs, working as switches which detect when water closes the circuit.
The design of the liquid distribution system was carried out taking into account sculptural aspects. In this way, the playing of the instrument presents interesting visual patterns due to the process of circulation of the liquids, corresponding to the activation and deactivation of the various pumps.
Using an interface of simple operation such as droppers are, it is possible to control music parameters in a direct way. The timing of the drip will determine the rhythm of the sound generated. Another possibility for the playing of the instrument is to interact with the liquid in a direct form by distributing it on the contacts by hand. In this way it is possible to obtain results of irregular rhythms. However, when operating in this manner, it is more difficult to control the results, being the behaviour of the liquid more unpredictable and aleatory.

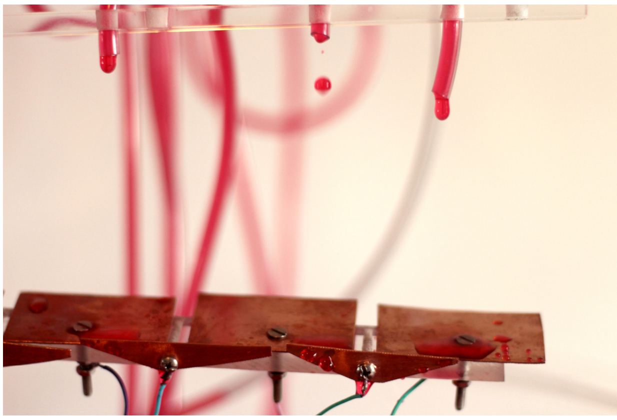

Figure 4. Detail of drops spilling on the contacts

Audio example 1 shows the sound resulting from a contact controlling a note[5]. By modifying the speed of the drip the tempo may be varied. Audio example 2 offers the polyrhythmic result of two overlapped contacts with different tempos.

3.3 Control module

The system for the generation of control events was designed based on an Arduino board (model Mega 2560). A rack was assembled, containing the board, as well as the relay modules, the input and output connections, and a user’s interface for parameter control in real time.
Each electrical contact is connected to an Arduino digital input. When the flow of water closes a given contact, it allows electrical conduction and a change of state is produced. Based on the detection of the various inputs, MIDI control events are triggered which provide a variety of options, aiming for the instrument to offer ample musical versatility.
Besides the options to control the drops by means of the droppers, several musical parameters are configurable employing the user’s interface. The control interface has two potentiometers, two rotary encoders and two push-buttons (incorporated into the encoders). An LCD display provides visual feedback: accessing a main menu and submenus, it is possible to attain a series of control alternatives in real time.
When a contact closure is detected, a Note On MIDI message is sent to the output; the parameters of this output are configurable by the player. The configuration options of the MIDI messages generated were established with the aim of obtaining richness and variety in the musical results. At the present stage of development, the module provides independent control of the following parameters: pump activation, pitch structures, octave range and intensity.

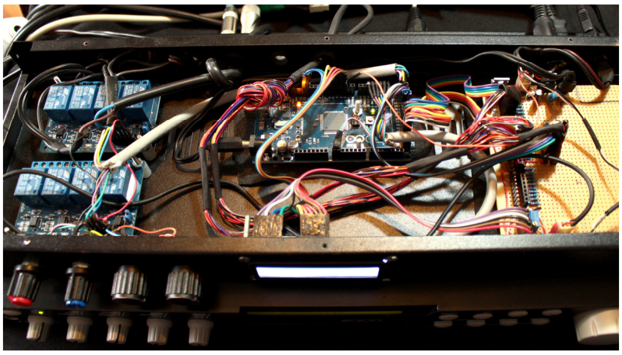

Figure 5. Internal detail of the control module

[5] Examples are available on the links on section 8.

By default, when a pump is activated it controls a note with a fixed intensity and range. By modifying the parameters in real time it is possible to adjust the values within which the messages will be sent.
The messages will be generated with an adjustable degree of randomness within a determined range. These options allow for a "macro" type of control. It is also possible to work at a "micro" level (the level of the sound materials themselves), from the parameters of the audio generator, as well as by adding effects or processes [6].

3.4 Sound generator

One of the main aims in the design of this instrument was its autonomy (to be able to function without the need of an extra computer). For this reason, the E-MU sound module Proteus 2000[7] was chosen for the generation of audio. This module was acquired second hand, due to its being an "antique" compared to the present state of development of commercial modules available in the market (synthesizers and samplers). The use of this module set a series of limitations that fed the creative process decisively, by means of the exploration of its possibilities and constraints. This does not exclude the chance to expand these possibilities, articulating or replacing them by other software-based sound generators, as future stages of development of the instrument.
Another key aspect in the design of Osiris consisted in defining a sound palette wide enough to provide timbral variety. This specific sound palette was determined based on the functioning of the control module and the detection of the gestures sensed by the interface of liquids. To this end, a study was carried out regarding the patches available on the synthesizer (such study is still in process since the module contains more than 1000 factory patches), choosing the ones that proved to work better in relation to the events generated by the drops and the resulting sound structures. These patches were classified according to their timbral qualities and chosen as a starting point for the musical exploration with the instrument.
In other words, the construction and programming of the control module was done taking into account the options provided by the sound generator, developing in this way what Jordà defines as "parallel design"[8].

3.5 Objectives achieved with the new design

The creation of this new version widens the musical options of the instrument, thanks to the design and construction of a microcontroller-based control module and the incorporation of a Proteus 2000 sound generating module.
Amongst the main objectives accomplished by this new digital version are the following:

- The definition of pitch structures, octave range and intensity by means of a real-time controllable user's interface.
- An ample sound and timbral palette, thanks to the use of MIDI and an external sound generating module.
- The possibility of adding variable degrees of randomness for the control of parameters, as well as availability to widen the musical alternatives according to new specific objectives by modifying the microcontroller programming.
- Higher levels of polyphony (limited only by the characteristics of the sound generator).
- Options to control a larger amount of pumps, allowing to expand polyphony and sound events density.

Figure 6. Control module and sound generator

4. MUSICAL POSSIBILITIES

The engine of generation of control events in Osiris is relatively simple. High interest musical options are determined by the control of the parameters of such events, and by the process of addition of several of these simple events, thus obtaining a resultant of higher richness and complexity.

Table 1. Real-time parameters of the control module

Option	Parameter 1	Parameter 2	Example
Pump activation	On / Off	-	Audio example 3
Pitches	Key note	Intervals, chords, scales.	Video examples 1-2 Audio example 4
Octave range	Minimum value (1 to 9)	Maximum value (1 to 9)	Audio example 5
Intensity	Minimum value (0 to 127)	Maximum value (0 to 127)	Audio example 6

The playing of Osiris allows for the use of various contacts simultaneously and the control of several timbre layers in an independent manner. It is possible to obtain higher complexity by means of the overlapping of various contacts, which allows for polyphony, polyrhythms, multi-timbrality, harmonic overlays, amongst other possibilities.
The configuration of the different musical parameters analyzed may be carried out independently in three layers. Each of these layers is assigned to a series of specific contacts, and sends information by an individual MIDI channel. In this way, different patches of the Proteus module can be used simultaneously. Video example 3 shows the functioning of Osiris as it is being played. At a musical level, we can listen to a structure that employs several timbres. Audio example 7 shows a fragment of the audio corresponding to the video example, and following, each of the layers individually.
Audio example 8 is another multi-timbral example, which uses two simultaneous layers in a low range. The overlapping of these layers with contrasting drip speeds provides a complex rhythmic resultant.
Finally, another option is the addition of processors and audio effects at the sound generator output (considering this electronic instrument to be "autonomous and open-ended" according to Tanaka's definition [9]). Audio example 9 and 10 show the resultant of different layers of timbres processed in real-time with effects such as distortion, filters, delay and reverb.

[6] About micro and macro levels of control, see [5].
[7] This module was built and commercialized by E-MU in 1999. The audio generation is based on samples recorded on its internal ROM memory, with the option to expand sounds by means of additional memories. This type of modules are also known as "Romplers".
[8] Jordà asserts that "it becomes hard – or even impossible – to design highly sophisticated control interfaces without a profound prior knowledge of how the sound or music generators will work (…) a parallel design between controllers and generators is needed with both design processes treated as a whole" [8].

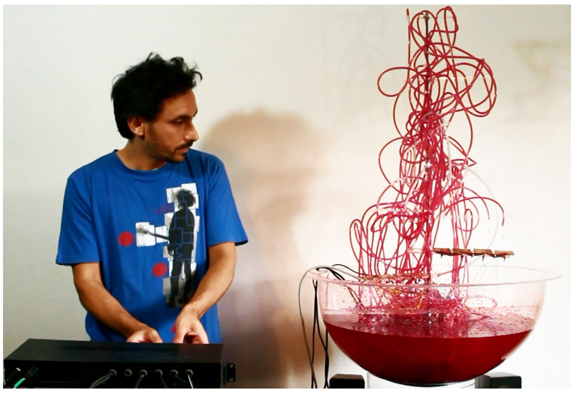

Figure 7. Operating the instrument

5. CONCLUSIONS

The design and construction of Osiris involved, besides the electronic design and the programming of the control module, working with the most diverse materials: acrylics, copper, steel, water pumps and hoses, amongst others. Also, the use of "antique" technologies such as the Proteus 2000 module and the MIDI protocol. In retrospective, I can assert that this was due not only to practical or cost-related matters, but also to process and aesthetic motivations. In this sense, I consider that this kind of restrictions enabled the development of original strategies that nurtured in a decisive way the creative process of the instrument.

The fundamental premise that guided this process was to build a device that allows a broad range of sound and musical possibilities, regardless of the degree of technological complexity. In general terms, the degree of development achieved involves a simple sensing system derived from the first analogue experiences carried out, and affects the rhythm and the global density of events; and other sound and musical parameters are determined by the mapping strategies employed.

A relevant consequence of the process of creation of Osiris was the chance to reflect upon the complex dialectic that is established between the technological development and the musical praxis, in the field of the creation and interpretation of a new electronic musical instrument. Michel Waisvisz explains:

> About my own experiences with gestural controllers I can only say that I fight with them most of the time. That's something that almost every instrumentalist will tell. But if you are in the position to be able to design and build your own instruments, and so many interesting technologies pop up almost weekly, you are tempted to change/improve your instrument all the time. This adds another conflict: you never get to master your instrument perfectly even though the instrument gets better (?) all the time. The only solution that worked for me is to freeze tech development for a period of sometimes nearly two years, and than [sic] exclusively compose, perform and explore/exploit its limits. [10]

The next priority steps in the work with Osiris will be in relation to the exploration and practice in the area of performance and the development of specific interpretation techniques. Secondly, the evaluation and implementation of technical improvements of the instrument, from the constructive point of view as well as the programming, introducing new levels of sensing, control and sound generation, amongst other aspects.

6. ACKNOWLEDGMENTS

I would like to thank Lila Mitchelstein for the translation of this paper, Bárbara Bilbao and Camila Matus for their comments on the original text. Also, Claudia Araya López and Leandro Sánchez Cozzi for their assistance on the visual documentation.
Special thanks to Andrés Rodríguez for his guidance in this research.
This work was developed with the support of the "Fondo Argentino de Desarrollo Cultural" (Ministerio de Cultura).

7. REFERENCES

[1] S. Mann. Natural Interfaces for Musical Expression: Physiphones and a physics-based organology. *In Proceedings of the 2007 International Conference on New Interfaces for Musical Expression* (NIME´07), pages 118-123, New York University, New York, USA, 2007.

[2] T. Nunn. Jacques Dudon´s Music of Water and Light. *Experimental Musical Instruments*. Vol. 3, No. 5. Nicasio, California, 1988.

[3] B. Hopkin. The Waterphone. *Experimental Musical Instruments*, Vol. 2, No. 3. Nicasio, California, 1986.

[4] A. Malvino. *Electronic Principles*. Glencoe / McGraw-Hill, New York, 1998.

[5] P. Scherz and S. Monk. *Practical electronics for inventors*. McGraw-Hill, New York, 2013.

[6] N. Collins. *Handmade Electronic Music: The Art of Hardware Hacking*. Routledge, New York, 2006.

[7] E. R. Miranda and M. M. Wanderley. *New Digital Musical Instruments: Control and Interaction Beyond the Keyboard*, volume 21 of *The computer music and digital audio series*. A-R Editions, Middleton, Wisconsin, 2006.

[8] S. Jordà. Digital lutherie: Crafting musical computers for new musics performance and improvisation. *PhD Thesis*, Universitat Pompeu Fabra, Departament de Tecnologia, 2005.

[9] A. Tanaka. Mapping Out Instruments, Affordances, and Mobiles. *In Proceedings of the 2010 International Conference on New Interfaces for Musical Expression* (NIME´10), pages 88-93, University of Technology, Sidney, Australia, 2010.

[10] M. Battier, M. Wanderley and J. Rovan. Round Table: Electronic Controllers in Music Performance and Composition. *Trends in gestural control of music*, IRCAM, Paris, 2000.

8. Links

Video Examples:
https://matus-lerner.blogspot.com.ar/2017/01/osiris-video-examples1.html

Audio Examples:
https://matus-lerner.blogspot.com.ar/2017/01/osiris-audio-examples.html