

# LOW COST DIGITAL LUTHIERY

Tomas Laurenzo.

Universidad de la República, Uruguay.

laurenzo@fing.edu.uy

## ABSTRACT.

This paper shows the working prototype of a mixed-media musical instrument we named *Tecnocardio* and focuses in the different techniques used in its creation. By its creation we investigated the least expensive techniques in digital luthiery hoping that it could help our future endeavors and also other artists with a low budget.

## 1. INTRODUCTION.

The recent years we have witnessed the birth of a new breed of engineer-scientists-artists that use technology not as mere consumers but also as creators, developing and crafting new tools for and ways of artistic production and performance, specifically new musical instruments (and new ways of interaction) have been created in a field known as digital luthiery (Jordá, 2005).

Coincidentally, new tools have appeared into scene that aim to bridge the conceptual gap that a more traditionally-oriented artist may face, MAX and MSP (among other tools), are a great example of artistic-performance oriented tools.

New media art describes a process where existing, new and emerging technology is used by artists to create works that explore new modes of artistic expression, ranging from conceptual to virtual art, through performance to installation art and involve new media in both how the work (or a component of the work) is conceived and created as well as the way in which it is presented to an audience (Arts, 2006).

This already-proved fertile field implicitly assumes that the artist has the *means to the media*. No matter what the media is or how it fits into the art-production scene (a raw medium, a tool, etc.), she must be able to have access to it in the very first place.

This obvious necessity is wildly overseen in the literature which does not take it into account when talking about the democratization (of access to, or creation of, information or art) that technology implies.

We can realize that this is indeed a very serious problem by taking a look at the prices involved. For example<sup>1</sup>, MAX and MSP cost 395 U\$<sup>2</sup>, a price that can't be afforded by a significant part of the artist population or the art institutions.

In a context of this kind (i.e. with virtually no budget except for the old hardware already available at our lab<sup>3</sup>) we attempted to create the Tecnocordio, the mixed-media, networking-enabled, gesturally-controlled musical instrument we are hereby presenting.

It is worth noticing that we had no previous experience with electronics. We consider this particularly important as it shows that other artists with no background in electronics can attempt this<sup>4</sup>.

This paper will show the instrument *per se*, and some of the techniques we used in its creation. The rest of it is organized as follows:

- Part 2 briefly describes the Tecnocordio itself.
- Part 3 showcases some of the techniques used.
- Part 4 presents the conclusions.

## 2. THE TECNOCORDIO

The Tecnocordio was<sup>5</sup> a mixed-media<sup>6</sup> musical instrument created using outdated and recycled technology. In the Hornbostel-Sachs (Von Hornbostel, et al., 1914) musical

---

<sup>1</sup> Price as of 2007-03-06, <http://www.cycling74.com>

<sup>2</sup> It may be argued that there are –at least in terms of software- free alternatives, as in PD vs. MAX. Although this is true for PD, which is a great and much used tool, by no means is the common case: e.g. GEM (the video component of PD) offers no competition to the much more sophisticated and potent Jitter (the video component of MAX).

<sup>3</sup> Not really “our lab” but the lab of the Electrical Engineering dept. of the School of Engineering of the University of Uruguay.

<sup>4</sup> It wouldn't be fair to omit that we did have some help from the staff of the electronic engineering dept. but we still believe that this help could be substituted with deeper internet searching. We would like also to point out that we were profoundly inspired by MIT ex-researcher Etienne Delacroix work, who worked at the lab at the moment.

<sup>5</sup> We refer to the Tecnocordio in past tense because its parts have been reused in other projects.

<sup>6</sup> One important aspect of mixed-media musical instruments is to recover the role of the visual appearance of the instrument, something often lacking in all-digital musical instruments.

instrument taxonomy it would be a chordophone, i.e. a string instrument, but it also generated synthesized sound and some real-time images.

We wanted to allow as much input techniques as possible, so it could be controlled (see Image 2) via MIDI, very basic visual gestures, real-time scripting, and scoring.

When designing the instrument, our main concern was cost: we were only to use the technological garbage we had in the lab (recycled with the techniques described in part 3), plus one modest computer (a 500 MHz Pentium III PC) and several much older PCs (66 and 100 MHz 386).

The instrument consisted in a metallic structure (made out also of recycled PC cases), which held the motherboards, the strings and the motors (these last two in a special resonant wood frame). Each motherboard controlled four motors, being able to play four strings.

All the PCs run Linux<sup>7</sup> and had old network cards, so we had a 10-baseT LAN linking them and the computer we used to control the instrument.

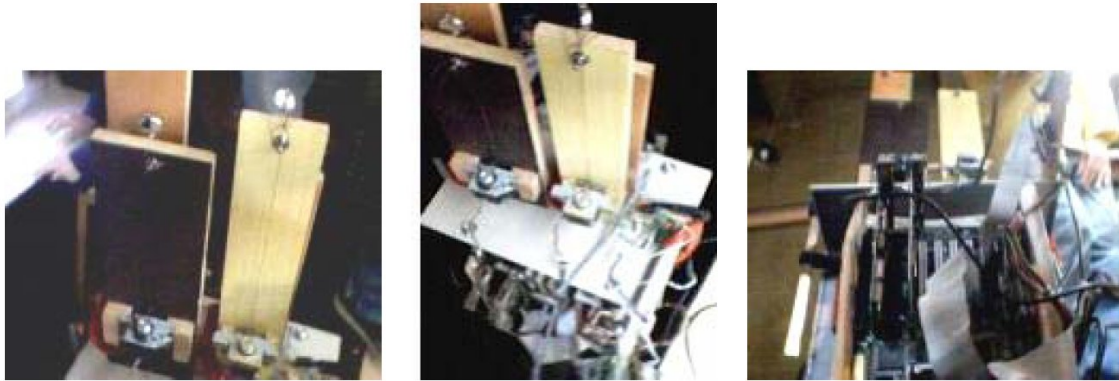


Image 1 - The Tecnocordio. Left: two strings and two stepper motors. Middle: more strings and the base with the motherboards. Right: the motherboards.

This computer (the Pentium III) ran our controlling software, written in Java, and allowed the instrument to be controlled by Java scripting (using BeanShell (Bea07)) and MIDI.

---

<sup>7</sup> We used a stripped-down version of Slackware Linux.

For controlling the Tecnocordio via MIDI one had to plug a MIDI controller to the MIDI-in of the PC. Our software translated the MIDI commands (only note-on and note-off were available) to the corresponding<sup>8</sup> commands to be sent to a motherboard.

Only note on and note off were supported and all note-on were played at maximum velocity.

If scripting were to be used for controlling, the user had access to both the mapping and the motors in direct form, being able to write commands of the form `playNote(A4)`, and `playNote(IP, motor)`.

It is worth noting that our implementation corresponds to a more general software architecture, where different inputs can be arbitrarily mapped to different outputs. In that framework, linking MIDI-in to the Tecnocordio was only a matter of setup.

Finally, although we fully implemented the architecture for the Tecnocordio, MIDI, scripting, software synthesizer, the Tecnocordio itself never surpassed the prototype stage.

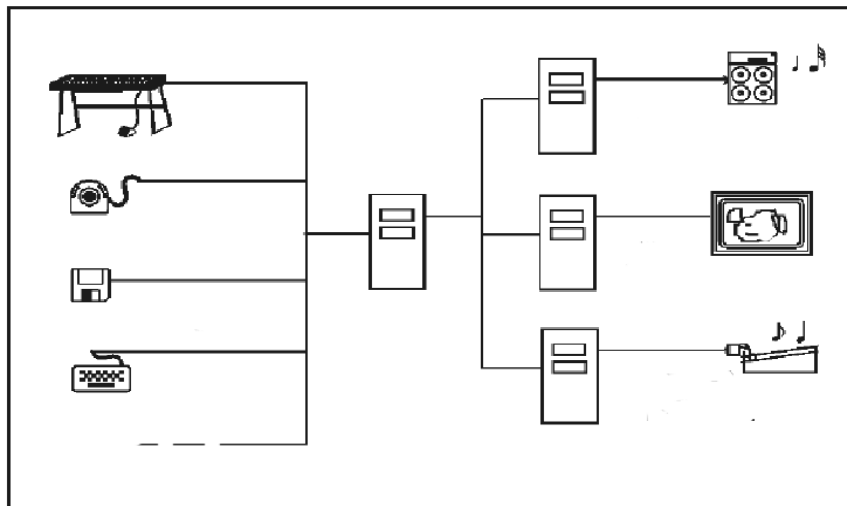


Image 2 – The Tecnocordio I/O; on the left the inputs, MIDI, gestures, scoring, scripting; on the right the outputs: synth, images, physically-produced sound.

---

<sup>8</sup> We had had a mapping (IP, motor) to MIDI note.

### 3. LOW-COST CRAFTING TECHNIQUES

Although the creation of the Tecnocordio and its architecture revised great joy to us, we believe that an important lesson of this work is that one can create a new musical, physically-based, musical instrument with (almost) no budget, and with just the most basic knowledge of electronics.

Our objective was rather modest: we were to create a new string musical instrument by using only the hardware already available in our lab at that time, which we suppose was a fairly standard third-world electrical engineering lab, we hope that this way of approaching the problem can be used by others to attempt more sophisticated endeavors.

Knowing that the Tecnocordio was to be a string instrument, the first problem we faced was to play the strings. We decided to stick to the simplest setup: a motor used to hit a guitar string, which would then vibrate in its fundamental note (Image 3 - A string and its stepper motor).

We used stepper motors recycled from old 5<sup>1</sup>/<sub>4</sub> diskette drives that happened to be in our lab. As we had no programmable hardware (e.g. a PIC), we created our own hardware drivers for controlling them, but then again we had no hardware for it, so we decided to recycle chips and PCB.

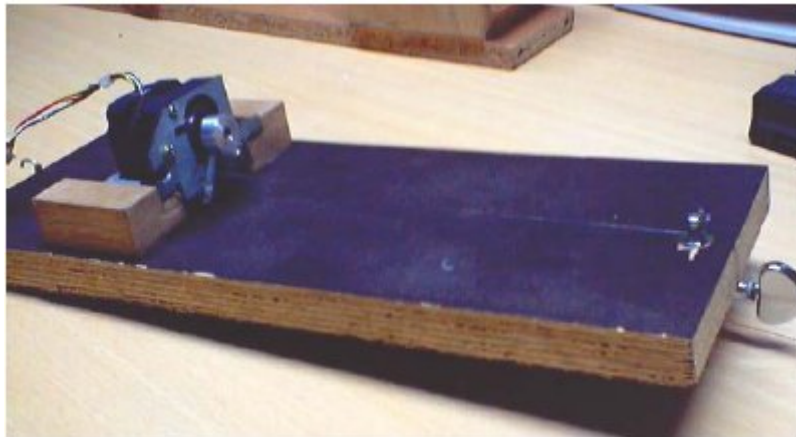


Image 3 - A string and its stepper motor

These motors have four coils that can be excited separately. By doing it in order we can get the motor to spin. A simple circuit for doing so is depicted in Image 4 – Very Simple

circuitry for controlling steppers, but for implementing it, we need some XOR gates and some way to obtain the 12V<sup>9</sup>.

The ULN2003 chips (ULN2003), have seven darlington arrays that we can use for leveraging the voltage and the 7486 (7486) family of chips have four XOR gates for controlling the logic. Both can be found in many outdated hardware, and we happened to have them in the boards of the same diskette drives.

To use them we de-soldered them using a paint-removing gun, and re-assembled them as is seen in Image 6 – de-soldering chips. The only caveat to this technique is not to get burnt.

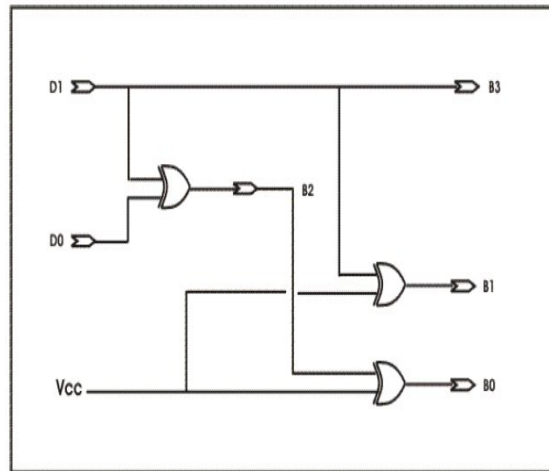


Image 4 – Very Simple circuitry for controlling steppers

The next step was to create a circuit with these chips. Our choice was to turn to the leftovers of our de-soldering and to cut and paste the PCB.

As is shown in the following images, it is possible to craft connectors and circuit boards by cutting and soldering PCB from old boards.



---

<sup>9</sup> The parallel port outputs 5V.



Image 5 - crafting PCB

By de-soldering chips, cutting PCB and recycling motors we had our basic modular piece of the Tecnocordio.

As the steppers were to be controlled by only one performer, we used our only *powerful* PC to act as the CPU of a distributed instrument, where the IP nodes had each four musical notes.

#### 4. CONCLUSION

This paper shows a string instrument we've created called Tecnocordio and shows some of the low-cost crafting techniques (recycling motors, de-soldering chips, crafting PCB) we've used in its creation.

By making emphasis on the low cost of the techniques, we aim to address the much overlooked economical problem that many artists face.



Image 6 – de-soldering chips

Also, being able to (at least partially) recycle and reuse obsolete technology for specific (and often not very demanding of processing power) tasks can be a strong way of fighting against both the digital divide and the so called e-waste.

But one should not forget that there are many problems that do require state of the art technology. We believe that old, recycled technology and new one can coexist and collaborate via networking. For our instrument we set up a TCP/IP network over coaxial cable that allowed us to have obsolete and new technologies interact seamlessly (it also freed us from many physical constraints letting us distribute physically the Tecnocordio: the different strings and components could be arbitrarily distant).

We hope that this attitude towards technology can help bridge the digital divide by providing new means of creation to artists and institutions that face economical constraints.

## 5. References

*BeanShell*. [Online] [Cited: april 16, 2007.] <http://beanshell.org>.

7486, Datasheet. 7486 Datasheet. *7486 Datasheet*. [Online]  
<http://focus.ti.com/lit/ds/symlink/sn7486.pdf>.

Arts, Australia Council for the. 2006. Support for the Arts Handbook. 2006, p. 109.

Jordá, Sergi. 2005. *Digital Luthiery, Crafting musical computers for new musics'*, *Ph.D. thesis*.  
Barcelona : Universitat Pompeu Fabra, 2005.

ULN2003, Datasheet. ULN2003 Datasheet. *Datasheet Catalog*. [Online] [Cited: 4 16, 2007.]  
[http://www.datasheetcatalog.com/datasheets\\_pdf/U/L/N/2/ULN2003.shtml](http://www.datasheetcatalog.com/datasheets_pdf/U/L/N/2/ULN2003.shtml).

Von Hornbostel, Erich M. and Sachs, Curt. 1914. *Systematik der Musikinstrumente*. 1914.