Knotting the memory//Encoding the Khipu_:
Reuse of an ancient Andean device as a NIME

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ABSTRACT

The khipu is an information processing and transmission device used mainly by the Inca empire and previous Andean societies. This mnemotechnic interface is one of the first textile computers known, consisting of a central wool or cotton cord to which other strings are attached with knots of different shapes, colors, and sizes encrypting different kinds of values and information. The system was widely used until the Spanish colonization that banned their use and destroyed a large number of these devices.

This paper introduces the creation process of a NIME based in a khipu converted into an electronic instrument for the interaction and generation of live experimental sound by weaving knots with conductive rubber cords, and its implementation in the performance *Knotting the memory//Encoding the Khipu_* that aim to pay homage to this system, from a decolonial perspective continuing the interrupted legacy of this ancestral practice in a different experience of tangible live coding and computer music, as well as weaving the past with the present of the indigenous and people resistance of the Andean territory with their sounds.

Author Keywords

Decolonial Aesthetic, Khipu, Media Archaeology, NIME, Performance, Tangible Interface.

CCS Concepts

• **Applied computing** → **Sound and music computing**; Performing arts; Media arts; • **Hardware** → *Sensor applications and deployments*;

1. INTRODUCTION

The khipu[1] was an information processing and transmission device used by the Incas and previous Andean societies. The word comes from the kichwa[2] language [khipu] which means knot. With this system, the information was knotted in wool or cotton strings and encoded in different kinds of values. A khipu consists of a central cord from which secondary strings are detached with knots of different shapes, colors, and sizes that constituted a set of signs that could be used to make numerical records or to account for important facts or events (figure 1.). The khipu has been known for its accounting and statistical utilities, but nowadays it has been discovered that the Khipus also contained several layers of memory that include not only arithmetic data but also economic, social, biological, historical, astronomical, linguistic and literary records [3] [19].

The western reading and vision of Khipus, obsessed with establishing their numerical and mathematical logics in them has ended up turning them into codes without a message (as what Barthes considers photography is) [14] just in simple cultural objects without soul that has been used only for the observation, and study and not as the functional tools, full of meanings that were until their destruction.

This project has been developed in the framework of the courses Playful Interfaces [17] and Media Archaeology of Interface Culture Master Program at the Linz University of Arts.

Using new media, physical computing, video, and sound software, this project aims to bring back the khipu in the construction of new sound narratives, following the legacy of the Andean ancestral peoples by granting new messages on the use of that code system as a critical response of that western readings and logics imposed in an exercise of the symbolic restoration and vindication of the erased memory of the original peoples with the practical use of this ancestral device in the current artistic field. Based on the original System the objective is the use of a contemporary Electronic Khipu made with conductive rubber cords sensors and a Teensy board as a live sound interaction instrument and MIDI controller, a tangible interface that wants to highlight the importance of cultural memory and historic reparation in a NIME.

2. RELATED WORKS

In the fine arts, the khipu has been the inspiration and object of artistic production for several artists who have used this device in their works, as is the case of the artist Cecilia Vicuña,[3] within the field of media and sound art, the installation of the Chilean artist Constanza Piña stands out. It consists of an astrological khipu woven with wool and copper wire that works as an antenna to amplify the sound out electromagnetic waves in the space [12].

After a review of references within this conference, no records have been found of the use of this device on NIMEs, but due to its cultural character and historical value, this research must mention projects that have taken ancient traditional musical instruments from different parts of the world and reused them in new interfaces:

Among them, are the *Gyil* African xylophone [18], the *Bodhran* (Irish frame drum) [9], the transformation of the *hyperpuja* for the interaction of the *Tibetan Singing Bowl* rubbed [20], or in the same line, there is the *Tibetan Singing Prayer Wheel* which works with gestural Control [22]. Inside of this revision, many of the traditional instruments have in common that they have undergone an electronic transformation such as the *ESitar* controller based in an Indian sitar [8], the medieval *Tromba Marina* [1], The *SlowQi*n as a reinventing of

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[1] Also Known as *Quipu.*

[2] One of the the the most important native languages of the Andean territory.

[3] http://www.ceciliavicuna.com/quipus

Figure 1. Ancient Andean Khipu
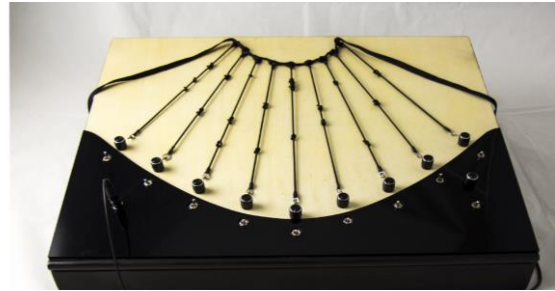
Chinese string instrument *the Guqin* [5]*,* or the *eHaegum,* the *eJanggu*, and ZiOm a set of modified Korean musical devices [7]. There is also the case of those that were reused as MIDI controllers as the series of instruments to playing the *Gamelan Elektrika*, inspired by the Balinese traditional practice [11] or *The Mutha Rubboard* based on the instrument used in the Zydeco music genre of South Louisiana (U.S) [21].

In another, more contemporary case, it is worth noting the reflection on the importance of remaking of instruments from the past in the example of *Persephone markII* [4] and due of their decolonial character and the process of creation they have had, one cannot fail to mention the *Pandivá* and the *Giromin*, electronic devices inspired by the tools used by local communities in Brazil [2].

Within another kind of artifacts related to media archaeology and the repurpose in NIME there are *Music's Cube* based in a Rubik's Cube [13], or *Cembalo Scrivano*, the audiovisual installation inspired by an old typewriter [6].

Although most of the references mentioned above refer to musical instruments -which is not the case of the khipu- the methodology of reusing a historical artifact and the modifications to extrapolate it to the needs of the present have been rescued from them.

3. ELECTRONIC KHIPU

The khipu has three-dimensional writing, is a tangible computer system that requires the body where not only the sense of sight is involved. Touch and listening are fundamental parts. [16]. With these characteristics as a premise, it has been designed and built the Electronic Khipu as an instrument in a MIDI controller for the experimental sound where the interaction is based on the weaving of different kinds of knots in real-time.

3.1 General technical description

As can be observed in Figure 2, the Electronic Khipu consist of a root cord and nine secondary strings made with conductive rubber strings sensors arranged on a box in which has been settled potentiometers to modulate volume and buttons to activate or deactivate the signals of each string. It has a board circuit designed for the connection of the strings and components that allow their operation and a Teensy microprocessor that sends the signals received with the rubbing of the strings to be knotted and also a cable attached to one of the fingers of the performer and connected to the ground of the instrument whose rub sends different MIDI type signals to the computer.

The computer receives these signals as impulses and frequency changes in MIDI signals that control the effects in recorded tracks and produce other sounds using Ableton Live software.

Figure 2. Electronic Khipu

The production process of each of the parts that make up the instrument will be detailed below:

3.1.1 Cords
Inspired by the traditional wool khipu (figure 1), this version has nine strings of conductive rubber cord stretch sensor[4] attached to a main rope of cotton. After a search of conductive materials and reference projects that had the properties required[5], the conductive rubber sensor strings was chosen over the existing conductive textiles and threads since they act as a variable resistance whose values can be mapped, and for the flexibility and ease of reuse it provides for untying the knots.

3.1.2 Base box and electronic system
As illustrated in figures 1 and 2 the disposition of the khipu in a box is based on the forms of the exhibition of Khipus in museums, with separate strings for their better appreciation and use.

To the upper part of the box are anchored the strings with screws, this union is hidden by the main cotton rope. In the lower part, it has small conductive metal fittings connected internally to the ground of the microcontroller that allows to close the circuit and receive the stable signal of the tension of the cord after being knotted. To facilitate its use, a button has also been added to the controller for each string that allows it to be activated in the DAW as well as a knob that allows the output volume to be controlled. And a female banana jack component for connection to the performer.

Inside of the box, all the wiring for all the components used is arranged in a modular fashion connected to the Teensy 3.6[6] microcontroller on a board circuit specially designed for this purpose.

3.1.3 Connection performer-instrument
The variety of sound textures caused by the different signals produced by the cords is possible in conjunction with the performer's skin conductivity. The touch and force used to make the knots produce different intensities. The connection is done with a cable connected with a male banana jack internally to the ground of the system and to the other side with a ring or bracelet used by the performer, thus closing the circuit in the touch of the string with the fingers, modifying the signals produced by each of the strings with this interaction. When the knots are made, the string is anchored to a small metal piece fixed to the box, that connects it to the ground of the electronic system, in a stable way graduated depending on the tension generated by each knot.

3.1.4 Sound
The Teensy board is programmed to act as a MIDI controller, the values of the conductive rubber string are mapped differently on each cord due to its length.

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[4] Sensors that act as variable resistors made of carbon-impregnated rubber that are generally used as measuring stretch forces https://www.adafruit.com/product/519

[5] The first ideas for technical set-up of the electronic khipu were inspired by this instrument also made of conductive rubber strings https://www.instructables.com/id/Arduino-Musical-Instrument/

[6] https://www.pjrc.com/teensy/

Ableton Live[7] is used as the DAW. Using the electronic khipu as a MIDI controller, each string has assigned a track with a pre-recorded sound that is modified by an effect chosen from the software, whose values will be mapped to work in relation to the string manipulation and the knots done. The diagram in figure 3. is the general technical disposition of the instrument to the performance.
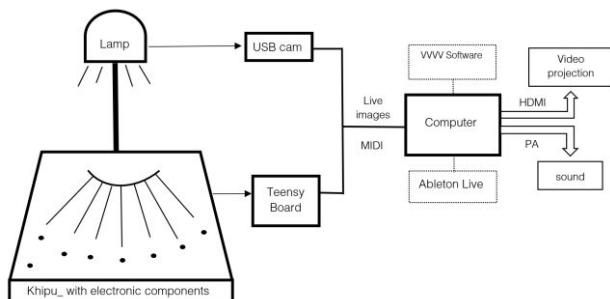

Figure 3. Technical diagram of Electronic Khipu

4. DEPLOYMENT IN LIVE PERFORMANCE

The Electronic Khipu has been tested in the performance Knotting the memory// Encoding the khipu_ where the instrument is the main interaction element. The performance is composed to pay tribute to this device. The experimental sound piece presented is filled with digital textures modified by a tangible live coding due manipulation of the cords and the knot-weaving that will encrypt a sound composition in the khipu influenced by the ancestral sounds of the Andes with a contemporary treatment.

4.1 Knotting the memory//Encoding the Khipu_

The artist Constanza Piña [12] asserts that to understand a khipu it is necessary to venture to make one, by making the knots it is possible to understand how it works and to learn to read and write it by weaving the codes. The electronic khipu is a NIME, so the whole process of its making-of has been extrapolated from the experience that encompasses its knowledge, in this case, to understand deeply the way to play the instrument one must have the experience of making and knot it.

In ancient times the Khipus were knotted only by "khipukamayuqs", (khipu knotters) [10] who dedicated their whole life to the codification and reading of these devices. For the performance, the figure of the khipukamayuq takes on special importance since it is the performer, the live coder, the person who has the data that codes in the knots, and who can connect to the khipu, knot meanings and produce the sound, the performer then becomes a contemporary khipukamayuq that in a kind of tangible live coding, records and encrypts through the knots a live sound composition.

4.1.1 Approaching to Tangible live coding

Live coding is an artistic practice that consists of creating and modifying algorithms to generate music and images in real-time while projecting the code in front of an audience. [15] This is usually done with the computer using programming languages and software designed for these purposes. in this case the hand-coding by knotting the khipu allows to think about its use in a kind of contemporary practice of tangible live coding where, the code is written, modified and transformed in the work of knotting generating different textures, sounds, and tensions. The algorithm is knotted live, and the audience can perceive the changes and make direct associations of what is projected and heard.

4.2 Playing with the Electronic Khipu

The Electronic Khipu is designed for a live sound playing experience whose code can be known and produced by live experimentation in the act of knotting. Initially, some traditional forms of numerical coding of knots [19] have been used and replicated as well as own interpretations of knots that have been generated with the rehearsals. the purpose of the performance is not to decipher the code of the knots nor to teach their language to the audience, nor even to explain what the device is or what it does. the performance wants to be a bridge between the ancestral media and the current technology in a claim of the most practical facet of the device.

On a more individual level, the performer's experience is described in a connection with her origins, in which she finds a way to knot together personal memories by creating her own codification of stories through sound.

The personal experience of playing with the Electronic Khipu could be translated to sculpting the sound with the hands through the weaving, despite its experimental character, like any instrument, which gains in mastery through practice, once are familiar the strings, the elasticity, the effects associated with them, their sounds and the capacity to write through the knots, it is produced by playing, a sense of malleability that controls and generates the sound by touch, literally weaving it.

4.3 Sounds Choice

For this performance, the general composition has been designed with sounds of ritual specter with different effects, from subtle noise to sounds with melodic shades and recordings of traditional instruments of the Andes, until textures denser and deeper to finish the composition.

The selection of sounds was arranged so that after the mapping of the strings the effects would produce a better response to touch with the performer and interact better during the weaving process and the kind of knots done. Besides the sound produced by the strings the performance also has some accompanying tracks that help to close the piece and create the atmosphere.

4.4 Graphic Representation

As in the practice of live coding, the performance has a projection to see the code that builds the sound, in this case, it shows the knotting work, the direct connection between the manipulation of the strings and the knots with the generated sound. To get the visuals, all the hand's movement and gestures of knotting are being captured by a camera in real-time using vvvv[8] software with dedicated images filters that provide a white linear image on a black background as a living drawing. (Figure 4.)

4.5 Live Performances

This performance has been presented at various renowned venues and festivals such as the Ars Electronica festival 2019 and at the Deep space 8K of the Ars Electronica Center, as well as other spaces that have allowed the instrument to be adapted to different stages.

4.5.1 Audience Experience

The general appreciation of the audience regarding the performance, after its presentation in different venues, is one of contemplation, with a score that is knotted live, the experience has been perceived as a sound narrative that is generated as the device is knotted, a story that is coded live by means of the knots, with several layers of sound that immerse the audience in the woven memory whose interpretation is associated with the movement of the hands in the knotting.

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[7] https://www.ableton.com/en/live/

[8] https://vvvv.org/

Figure 4. Complete performance setting up at the stage

5. CONCLUSIONS AND FUTURE WORK

This paper has presented the current results of theoretical and practical research about the use of old interfaces from the Andes in new instruments for musical expression, its develop and use in live performances. The khipu is a device that lends itself to these purposes, it is a work in progress inclined to technical improvements.

With the electronic khipu a first approach is made to what could be called tangible live coding, since the khipu, even transformed into NIME, is still a computer and the sound results vary in real-time according to the coding made by the knotwork and the different values produced when the strings are tightened. This is a quality that will continue to be studied for better implementations.

*Knotting the memory//Encoding the Khipu_* is only the first performance made for the use of this instrument, it is expected to develop other pieces in which the khipu can be used both as a main element or as an accompaniment. As well as the development of NIMEs from the reuse of other ancient Andean interfaces that can form a series of instruments for audiovisual performance.

The coding done on the knots also works as a score that is recorded during and at the end of the performance, taking advantage of this feature that has not been used, a tracking system or recognition of the knots in real-time will be developed to create another type of sound and/or visual interaction with it.

Following the transformation of the Electronic Khipu, besides its use as a MIDI controller, another facet to be carried out in the future is the development of a synthesizer independent of the computer using the same dynamics of interaction, with the string knotting and sound generation by touch.

6. ACKNOWLEDGMENTS

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8. APPENDIX

A short video of the performance is available:
https://vimeo.com/410816086