Inversus

The Sensitive Machine

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***Abstract*—Inversus is a digital interactive installation that explores the relationship between user actions with common objects: lamps, speakers and fans. It is an interactive machine that shifts the conceptual understanding a user traditionally has about a specific object, making people wonder: why should a lamp be used only to illuminate? In fact, lamps, speakers or fans are commonly used as output interfaces, imagine now, what would happen if we turn the output into an input interface? This machine explores an inversion on this relationship by using lamps as light sensors, speakers as pressure sensors and fans as blowing sensors.**

Keywords-HCI; audiovisual instrument; DIY; user experience; interactive installations.

I. Introduction

Electronic devices are designed in general with a specific function. Today, many electronic devices are getting smarter with generic purposes, sensing the environment to respond to all kinds of inputs providing a wide range of capabilities. Devices that are designed for one main purpose can be used with a different one depending on the user intention. One can use a smart television to make a phone call, or use a smart phone to watch television. There is a shift in the way devices and objects are designed and in the way users relate to them. We live in a sensorial age where sensors are included in every day objects. But, instead of replacing all the objects and devices with smart new ones, we might try to recycle them. With the "Do It Yourself" (DIY) approach, ordinary people have the power to change and be creative to find new uses for their old devices. Our project challenges participants to discover and explore new applications for traditional one-purpose machines. Inversus, encourage the participants to rethink the original functionality of the objects into other potential uses, searching for new capabilities and combinations. [1]

Inversus is a sensitive machine that captures human interaction to produce sound and visual kinetics. It is a performing instrument that gives life to a mechanical flower, which spins when someone blows into the machine producing an animated shadow similar to the shadow puppetry effect (Figure 1). A virtual marionette lives inside the machine that reacts to the pressure of four sensitive pads; this marionette is rigged with virtual strings that are mapped to the pads that make them squash and stretch producing animation, like pulling the strings from a marionette. Based on human interaction the machine generates animation in the physical and in the virtual space in the mechanical and in the digital domain enhancing the user experience. This audio-visual instrument made from a washing machine spins a

Figure 1 – 3D simulation of the machine with the shadow of the flower projected on the wall.

physical colorful wheel after sensing the interaction, mixing all the media elements as a metaphor for the real washing machine. Users are familiar with these common objects and recognize their original function, but when they start interacting with Inversus they realize that it as a different purpose. They experience a strange reaction to a familiar object and explore its new potential making a dialog with the machine.

The remainder of the paper is organized as follows. Section II presents the design principles and describes how the idea was developed. Section III describes the implementation of the system and framework. Section IV addresses the impact of the interaction in participants. Section V presents the conclusion.

II. Design

The idea of building a machine from recycled materials was influenced by the toy hacking spirit and by an ecological thinking. Inversus was designed based on the way we play musical instruments with three types of interaction: i) striking a drum with the hands, ii) moving the hands above a theremin, iii) blowing air to a flute with the mouth. These gestures were adapted to present distinct interaction experiences based on the sensitivity of each sensor divided into three categories: Touch – by touching the color pads the

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user triggers sounds that respond to the pressure (like playing drums) and animates a virtual marionette that reacts to the pressure and represents the mechanical body;

Motion – by moving user hands above Light Emitting Diodes (LED) it produces a continuous sound (sound keeps playing until the hand moves away from the LED) similar to the interaction with a theremin instrument;

Blow – by blowing a fan, the user changes the frequency of sounds and spins a mechanical flower producing a shadow animation in the wall that represents the organic body.

In our methodology we searched for electronic materials that could be recycled into sensors. And although we did not seek total accuracy the diversity of the sources brought variable results. Our challenge was to create a balance between all the sensors and build an instrument that could be played by any user distinguishing the sensitivity in the different interaction methods.

Inversus was made from the fowling recycled materials: the chassis of a washing machine was used to build the case and to provide a link to familiar objects; the pressure sensors were made with piezoelectric from small speakers; LED´s from toys were used for building the light sensors; the blowing sensor was made from a computer fan. In this way all the objects were employed with a different purpose from their original design.

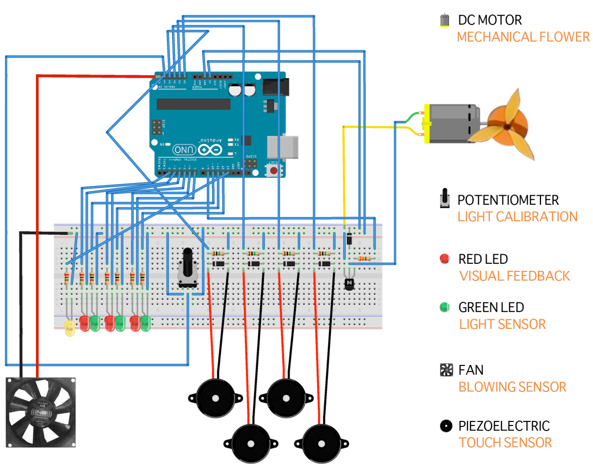

Figure 2 – Orthographic top view from the connection sketch with the input sensors and the output motor.

Using LED´s as photodiodes we can build low-cost light sensors [2]. A LED is basically a P-N junction, an interface between two types of semiconductor material that conducts electricity in two different sides. If a photon (light particle) penetrates the region around the P-N junction it can potentially interact with one of the atoms transferring it´s energy into the atom´s electron creating an electron hole pair. The electric field across the region causes a tiny current to flow, known as the photo current. Because the junction area of the LED is small the result current is also small. Adding up photocurrents over time makes the diode look like a capacitor and will increase the result current.

III. MACHINE DEVELOPMENT

To implement this solution we used the Arduino microcontroller, which provides configurable pins making it possible to change the direction of the current flow. We wired up the LED´s to the Arduino connecting the anode (positive) of the LED to a digital pin and the cathode (negative) to an analog pin (Figure 2). First, we charge up the capacitor by making the anode negative and the cathode positive in a short amount of time. Then, we take a reference measurement, reading the analogue voltage and waiting for the photocurrent to be integrated. Finally, the voltage is measured again and subtracted from the reference value. LED´s are sensible to thermal noise and are not precise as light sensors, in particular in dark environments. A potentiometer was included to calibrate the sensitivity of the LED´s to increase the accuracy of the readings face to the light environment. For pressure sensing, we used a piezoelectric element [3] from small speakers attached to foam pads [4]. Foam is a good material to attenuate the pressure impact and to expand the area of interaction. We connected the "piezos" through resistors and diodes to the analog input. The musical note velocity increases proportionally to the pressure that is made in the pads like in a real drum. The blowing sensor was a PC fan connected with two-wires, one connected to the ground and the other connected to the analog input. Based on the blowing strength, two DC motors increase or decrease the rotation of a mechanical flower and of a colorful wheel.

Our framework is based on serial and network communications that link hardware to software. Sensor readings from Arduino are mapped to control and note messages via MIDI protocol, used in musical-based applications, and sent through the serial port. Messages from the serial port are then routed to a virtual MIDI port using the software hairless-midiserial that allows MIDI-based applications to capture the messages. The messages are then mapped to Ableton Live, a sound application that triggers and shapes the sound. To route the messages into animation-based applications, we use the visual programming environment Pure Data to convert the MIDI protocol into Open Sound Control (OSC) network protocol, which is available in many multimedia applications. The OSC messages are then received in Animata, a real-time animation software, and mapped to a skeleton of a virtual marionette that reacts to the pressure of the Pads.

IV. INTERACTION

We design Inversus to generate an emotional response to participants, motivating them to play and discover cognitively the interrelations between their actions and the result in the environment.

By providing a multisensory experience the participants have the feeling of embodiment in the interaction with the machine, which is enhanced by the relationship between action, cognition and the environment [5]. The distinct interaction methods presented in this installation provided an opportunity to understand how users establish their communication with an unknown interface. We used some design conventions, such as shape, color or spatial distribution of the controllers that provided some interaction clues.

Figure 3 – Inversus installation presented in a art exhbition: Cheia, Póvoa do Varzim, Portugal.

Inversus was available for public interaction in two artistic exhibitions during two months (Figure 3). About 300 people attended the event. We performed a pilot study with 10 participants. We observed in detail the participants interaction and behavior with Inversus. From the observations, we detected interesting trends in embodiment interaction [6] that open new lines for further research. We found that most of the participants took some time to analyze the device before trying it, beginning their interaction by touching the pads seeking a relationship between the strength of their actions and the intensity of the sound and animation. After this understanding, most of the users that were observed moved their attention into the blinking LED´s by touching them. And although, not touch sensitive the light occlusion occurs producing an effect in the environment inducing the user in how to interact, establishing a relation between their hand position and the sound and the light of the LED. Participants approached the fan wheel in the last stage using their hands, and again, the effect produced in the environment pointed to the correct way of interaction. Changing their interaction behavior and by blowing to the fan, they realize that the fan wheel spins faster producing a more intense modification in sound, as well as making the mechanical flower to spin, producing a shadow animation in the wall. After the explorative phase and knowing how the interface works, participants expanded to a multimodal interaction combining the controllers like playing drums. By making it´s own cognitive observations and by establishing relations between their actions and the environment the participants become embodied with the a strange interface.

V. Conclusions

This interactive installation demonstrates how to “hack” electronic components used as output devices found in everyday objects and applied them as input devices in a different application domain. Recycling technology in an innovative way presents interesting challenges to users that can increase the feeling of empowerment and can contribute to novel interaction methods and applications. Two examples of the diversification of use of specific purpose technology can be found in game controllers such as the adaptation of the Nintendo WII remote as a low-cost interactive whiteboard [7], or in the adaption of Microsoft Kinect as a 3D scanner [8].

Inversus challenges the participants to interact with a machine that looks familiar, but presents unknown options and functions. It gives the participant the possibility to re-think the interaction fundamentals behind everyday objects. The participant is invited to discover the relations between the input sensors and the audiovisual output, and to realize the sensitive capabilities of inverted devices from recycled materials. As a result of the interaction experience, we hope to instill in the participants the desire to explore and create new communication challenges by re-defining the concept, usage and interaction mechanism of common objects.

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