TRACES: Exploring Manipulation of Time in Physical Space Through an Interactive Installation

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ABSTRACT
In the following paper we discuss the development of the interactive installation *Traces*. The work was created to investigate the possibility of seemingly manipulating the dimensions of time and space in physical terms, through the aid of technology. We used hanging fabric strings to design a space that senses people's touch and re-enacts it by setting the strings into motion once the action is done. The paper concludes with a discussion on potential limitations of our study and opportunities for further development.

Keywords
Tangible experience, reactive installation, exhibition, technology, situated actions

INTRODUCTION
We often catch ourselves wishing to go back in time and relive things, without realizing that this possibility is constrained to our memory. Due to our ability of reasoning and thinking, we feed the idea that regress is possible in reality. Not surprisingly, computers reinforced this belief. Undoing and re-doing an action has turned into something as simple as pressing a key on a keyboard. The possibility is at the tip of everybody's fingers, at least in the virtual world.

As envisioned by Weiser [1], technology is increasingly pervading our environment. Ubiquitous-, tangible- and social computing have been rapidly gaining importance since the embodiment phenomena called attention of the HCI community. At the current pace, it will not be long before we reach the point at which the virtual and real are completely intermingled. One of the consequences that most directly affects users is the possibility of seemingly manipulating time and spatial dimensions in physical terms. How will the non-linear time and space allowed by digital systems integrate with our sequential reality? Will the irreversibility of actions ever become obsolete?
Will time and space just like our remembering process, allow regression without loss?

Although these questions remain unanswered, it seemed relevant for us to bring this debate to the public. Therefore, we developed an environment in which an action of the visitor could be physically replayed through the aid of technology. Our aim was to research and build a medium, that would introduce the possibility of reversibility in physical terms. The experience envisioned had the goal to make people reflect about the possibility of reliving things in reality. Hopefully, it would raise questions such as whether there are situations in which regress is actually possible, or if one day it will be feasible to literally go back in time and space and relive things. And even further, would this possibility actually add or improve something in our lives?

In this paper we start by discussing existing examples of works that contributed conceptually or formally to the creation of this experience. Following this, we describe the process of turning the envisioned ideas into a concrete project. We also briefly demonstrate how the installation was experienced and perceived by the public in a specific exhibition context. Subsequently, we describe an early implementation of the first prototype. The paper concludes with an informal analysis of the results and with some remarks of how the installation could be further developed in order to improve the user's experience.

RELATED WORKS
Some of the issues considered in this paper were also investigated by others, specially in the media art field. 'Measuring Angst' [2], a work by Jonathan Schipper, poses similar conceptual questions. It consists of a mechanical structure that continuously reproduces the event of a glass bottle being broken and followed by its broken pieces being "reattached" (a movement in the reversed direction). In doing so, the artist poses the question whether the possibility of going backwards and forward in time will ever be feasible in the physical world through the aid of technology and science.
'The penetrable installation series' [3] by Jesús Rafael Soto consists of colored hanging plastic strings, whose collection compose penetrable geometric solids floating in the space. It was used by us as formal inspiration, since their materiality naturally creates a space that affords tactile interaction and makes visible the disruption that visitor's

actions provoke in an environment.
'Light Strings' [4], by Jinsil Seo and Greg Corness, is an environment consisting of hanging fiber optics, whose glowing patterns are formed according to the visitor's touch. This installation was also taken as a reference because of its research into possibilities of computer mediated interaction with a tangible, responsive field, composed by strings.

EXPERIENCE

With these concepts in mind, an installation called *Traces* [5] took form, in which the spectator's engagement and tangible experience play a central role. The space measures 2.60 (w) x 1.30 (d) x 2.90m (h) and consists of hanging fabric strings, grouped in 32 clusters which are distributed in a 8x4 matrix. Visitors can freely touch and/or enter the space. The responsiveness of the installation operates in two modes: Firstly, it senses and records the movement of the user. Secondly, it replays the path chosen by the visitor. By walking through the strings, visitors are performing an action, making choices, sensing the environment and, finally, provoking a change. Once the space has been left, the touched strings are set in motion. Thus, reminding the visitors that their traces were left behind in the installation (Figure 1).

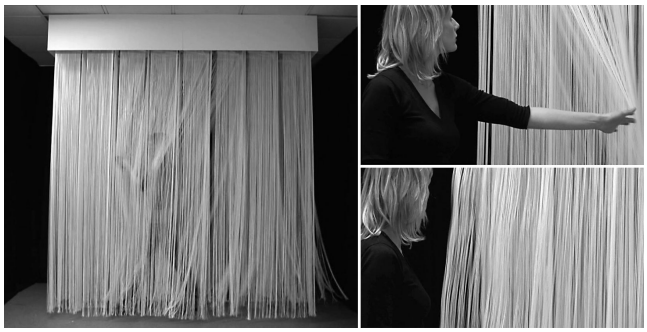

Figure 1: *The Spectator's action and the reaction displayed by the installation*

The idea of bridging the digital and the real worlds shaped a space that helps visitors to visualize the possibility of re-enacting events in physical terms, through the aid of technology. The awareness of time and space needed to be present in order to evoke the impression of reliving an experience. So, the exploration of visitor's movement seemed an adequate approach to naturally incorporate the aspect of doing an action over time. Consciously, matter was the medium chosen to visualize the spectator's actions being re-enacted. The use of screens, light or sound would not have been concrete enough to bring the necessary physicality to the installation. The tangible experience emphasizes the spectator's sensory perception of the concept.
During two weeks in January 2011 the prototype was shown on the Media Technology MSc Exhibition 2011 [6] at the OPEN | MAKERS gallery [7]. Within this context, the installation proposed a sightly different mode of interaction. Instead of replaying the visitor's touch, the path chosen by the visitor was played in reverse, therefore moving backwards in time. During that time, the installation was partly working, which meant that the paths chosen by the users were not necessarily replayed in the right order and that random paths were played occasionally. Nevertheless, empirical observation showed that visitors not always associated the reversed movement with the action done by them. Many visitors expressed that the relation would have been clearer if the strings mimicked their movement in the correct order instead of in reverse. In spite of that, the overall response was enthusiastic. The installation easily attracted and engaged people to interact with it (Figure 2).

Figure 2: *Traces installation exhibited at OPEN | Makers*

IMPLEMENTATION

During the implementation of the project, all structural aspects were designed specifically for the installation. Lightweight materials were used to ensure safety and to prevent the ceiling from carrying a heavy load. Furthermore, everything was planned to allow for easy dis-assembly and transport. On the technical hardware side, much of the technology was repurposed to allow for movement and sensing in the installation.

In executing the concept, the installation was designed to be modular, making it expandable beyond it's current dimensions. The current installation features two linked modules, each 4x4 matrices of grouped strings. Such a group of strings, referred to us as a cell, can move and sense movement individually from the other cells. Each cell is hung with elastic bands from the skeletal frame. This allows for fairly rough interaction without straining the frame. Furthermore, it enhances the displacement of the cell when it is touched, which aids the detection of motion.

Movement within a cell is driven by a DC-motor with a weight attached to it's rotary axis. When the motor is turned on, the weight causes a displacement of movement which in turn propagates as vibrations throughout the entire length of the strings.
Sensing is implemented using Hall sensors, which detect changes in the surrounding magnetic field. Each cell has a container attached holding a magnetic pendulum hanging

within it, right above a hall sensor. A slight touch of the cell's string causes the magnet to swing within the container. This movement is subsequently sensed by the sensor.

Two Arduino micro-controllers [8] are used. These micro-controllers provide a platform for quickly prototyping electronics. One was used for sensing and one for controlling the actuators. Both Arduinos communicate serial data to the computer running the software that interfaces with the installation. This software was written in the Processing programming language [9]. The software records which cells are touched during interaction. When a recording ends, the program determines and recreates the path using the sensed data, and plays these paths back by switching the cell's actuators (DC-motors) on and off.

After having played back the path, the installation rests for ten seconds. This is a physical limitation of the installation, as a short period of time is needed for all cells to become completely still. This prevents unintended movement from being picked up during the sensing mode. The work is powered by two 230 volt power supplies of 20 amperes.

DISCUSSION

The early implementation of the installation successfully achieved its goal in terms of creating a computer-mediated tangible environment that is capable of registering and playing people's movement based on physical interaction. The prototype proved to easily attract and engage people in a tangible experience. Empirical observation and informal feedback was collected during the two weeks that the installation was exhibited to the public. These results showed that after experiencing the work, people were stimulated to think about the presence and intervention of technology in their physical environment.

Technical difficulties, especially related to timing between sensing and actuating modes, leave room for improvement. Conceptually speaking, the interaction should also be better designed in order to help visitors associate technology with the possibility of non-linear manipulation of time and space in reality.

The success provoked by the materiality of the installation, reported by many as aesthetically pleasing and inviting, opened new opportunities for further research into using the space as a display-medium. Different patterns of strings animation upon a user's actions as well as reactive projection are examples of what has been further investigated by the group.

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