A Multi-touch Tabletop for Robust Multimedia Interaction in Museums

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ABSTRACT
The introduction of interaction technology in museum settings requires special care in different aspects including the relations with the different participants (public, artists, and curators), and the ability of the technology to provide rewarding experiences over extended periods of time for a demanding audience. This paper describes a hardware and software multi-touch table deployed in a contemporary art exhibition with many visitors. The design requirements are discussed and presented along with the development process. The paper also focuses on the different interaction and navigation mechanisms available and how they are used by the visitors and participants.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces.

General terms: Design, Human Factors

Keywords: Multi-touch, User experience, Social interaction, Design, Technology and Museums

INTRODUCTION
Regarding interactive technology, museums are a natural laboratory given the diversity of the visitors and the opportunities for interaction. The project described in this paper started with the initial motivation of building a physical/digital artifact that would be appropriate for museum spaces. Initial discussions among the development team, the artist, and the museum/curator led to preliminary design decisions which are further specified in the third section and resulted in the development of a large multi-touch table and a software application. Multi-touch is not advantageous in all situations but for a large shared physical installation in a public space, with different publics and age groups, it is certainly a solution to consider.

Most of the existing DIY solutions are used in confined and short lived settings, with a relatively small amount of users. In the case of the project reported here it was a large scale art exhibition with a high probability to attract many visitors. As such, special care had to be placed in the physical table design as described in the Hardware section. There was a need to match the research project questions with the fact that the proposed solution should be as effective as possible in exploring the art exhibition. Some adjustments had also to be done during the two and a half months that the first exhibition lasted.

As research questions, discussed in this paper, we consider both the challenge of building a software and hardware system for the purposes mentioned above as well as dealing with the social and interaction aspects that are fostered by having the system in a public space in the context of an art exhibition. Using a technological artifact as a mediator and a way to replace/augment the guest book, adding meaning through tags, and allowing for the visitors to navigate in the virtual content related with the spatial content are chief questions in our research. In this project, we have used a large physical object instead of mobile devices for several reasons including: (1) a large shared physical object allows for a different relation with the virtual information and also with the other pieces; (2) the proposed experience is not intrusive and for the numbers of visitors that were expected it is much easier to manage; (3) the interactive table promotes a social experience, acting as a meeting point, that could lead to interesting and yet informal collaboration scenarios, where groups such as families could participate.

RELATED WORK
The constant need to keep up with technical advances, coupled with the increasing sophistication and expectation of visitors due to the rapid advances in technology, are the challenges referred in [6] for the introduction of new technologies in museums. The use of tabletop displays has been a common practice, since it provides a collaborative

Figure 1: Interactive multi-touch tabletop.
atmosphere, which benefits the users [3, 11]. It is common to see interactions in a group or family [5]. Several tabletops were introduced in museums settings. However, most tabletops [3] only allowed visitors to interact with images or text. The use of participation mechanisms allows for greater engagement of the visitors with the art collections in museums. An example is MobiTags [2], a tag system that enables museum visitors to label objects from an open storage collection. In terms of technology the use of multi-touch tables has been around for many years [1]. However, the recent hype in this technology was initiated by the publication of the FTIR method in [4]. Since then a large number of projects has integrated multi-touch capabilities. One significant project is the ReacTable [8], a music performance table that introduced a multi-touch framework called ReactVision. Commercially there are also multi-touch devices such as the Microsoft Surface and the Apple iPhone. Today multi-touch is being used in a variety of social and multimedia projects [3,7,11], including museum settings. As stated in [10], the multi-touch technology is now entering a plateau of productivity where the number of projects using these interfaces is increasing considerably.

**DESIGN PRINCIPLES AND PROCESS**

The system was deployed in an exhibition during the period between March 1st and May 18th, 2010. The exhibition had more than 178,000 visitors. The solution was available to all types of museum visitors, without any kind of interference in the users’ interactions. The museum has a permanent collection and parts of it are displayed from time to time, but the exhibition program is essentially composed of temporary. In the case of the project reported here it was deployed in an exhibition of an art collection that includes thirty five artworks. One of the main requirements was the representation of the entire art collection of the exhibition with all the semantic information about each artwork. The interface should be a collaborative system that can be used simultaneously by several people in a public space. The visitors should have an entertaining interaction with the pieces in the exhibition and gather new information from and about them. They may be allowed to imprint their own mark on each piece and get feedback regarding the artworks, creating a community around the exhibition contents. Additionally, the interface should promote the production of folksonomies and arouse participation and active discussion around each artistic universe.

**HARDWARE/INTERACTIVE TABLE**

We were interested in creating a large interactive area, accessible to several users at the same time and robust enough to survive in a public space for months while being interfaced by thousands of people. We were aiming for an 80 cm tall table with a multi-touch surface area of 133x100cm centimeters and decided to construct the table from scratch. The construction of several DIY setups for optical multi-touch systems is described in the NUI Group wiki page. Our final setup is based on the Frustrated Total Internal Reflection (FTIR) [4] system. Several experiments were also conducted with other techniques such as the Laser Light Plane (LLP), and a final comparative table is presented (Table 1). The FTIR horizontal table (Figure 1) uses a data show projector, a mirror system, a PS3eye camera modified for infrared vision, an infrared LED ribbon, a compliant surface, sound speakers and a laptop.

The top layer of the compliant surface is a semi-rigid polyethylene terephthalate (or PET) sheet 0.8mm thick. Since the PET is transparent, a tracing paper layer was added to act as diffuser for the image. It is required to glue the tracing paper into the PET avoiding the creation of bubbles, glue stains, scratches or any abnormality across the large area. The resulting layer is then flexible to bend with a touch, the PET has a plastic look and the image quality is very good. Finally, the silicone solution has to be deployed on the tracing paper using the Tinkerman method. The tracing paper is glued to the PET, thus it is rigid. This rigidity prevents the TP from reacting with the silicone solution and creating ripples and wrinkles. Although this is a desired effect, the silicone base has more difficulty to adhere to the TP. After a while this causes the silicone to break and holes start to form. To solve this problem, an extra layer of tracing paper was added, as seen in Figure 2. The idea is having a first layer of tracing paper with silicone and a second semi-rigid layer of PET with tracing paper. The first layer will form ripples and wrinkles when the silicone is applied. The second layer will hide those ripples by applying weight and because it is not transparent. This will make the silicone react and adhere to

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1 NUI Group Wiki page describing several methods for the creation of an optical multi-touch screen: http://wiki.nuigroup.com/Hardware

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![Image](http://example.com/image.png)

**Figure 2: Surface of the interactive table.**

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**Table 1: LLP vs. FTIR method in a multi-touch table.**

<table>
<thead>
<tr>
<th>Comparison</th>
<th>LLP</th>
<th>FTIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Resistance</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Surface Aesthetics</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Clean Detection</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Detection Strength</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Sensitivity Regulation</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Security</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
the TP in the first layer while maintaining a flat look on the second layer.

INTERACTION AND COLLECTION EXPLORATION
Taking advantage of the possibilities allowed by the hardware setup, the multi-point interactive application explores the notion of a collaborative environment where the museum art pieces can be revisited and the opinion and feedback of the visitor can be recorded.

The software development component was carried out using openFrameworks, an open source toolkit for creative programming of interactive applications. This component uses the TUIO protocol. It enables the creation of touch gestures combinations needed to interact with the interface. Community Core Vision (CCV)\(^2\) was used to detect multi-touch events and track the fingers on the surface.

The layout of the interface had to be adapted to the physical device. Taking into consideration that the table display resolution was 1024x768 (133x100cm), several aspects had to be considered. For example, selection or touch areas should be at least 4x4 cm. Because the projected image is rather large, every single pixel is clearly visible which causes distortion in the image being projected. This obstacle is also exaggerated by the user's physical proximity to the surface. To minimize this effect it is necessary to re-think the typographical choices and after several tests, the chosen fonts were ITC Avant Garde for titles and buttons and Arial Regular for texts.

Features
The user interface, shown in Figure 3, consists on a set of black and white images of circular shape, representing the artworks of the art collection. The artworks are scattered along the interface on a white background, as seen in Figure 3a, with a predefined initial position. The main features of the application are: (1) artwork navigation, (2) artwork details, (3) questionnaire, (4) assign tags, (5) tags navigation, (6) guestbook and (7) casual game. The interface includes a button that shows the entire network of connections between the artworks, resulting of the relations between tags. At the bottom of the interface a message "Drag here" invites the user to drag the circles to the interaction area. Whenever an artwork is left by the user out of its initial position it automatically returns to the initial position. After dragging the artwork (1) to the interaction area, the main interaction window is displayed as seen in Figure 3b. The user can consult an artwork’s information preview (2). Images and videos that represent the artwork are displayed, as well as the artwork’s name and a list of assigned tags. Each tag in that list contains an indication of the strength of the relationship between the tag and the artwork. There is also a menu that allows consulting the complete and detailed information about the artwork (2). This includes the public participation mechanisms where comments can be consulted or added (6), and tags can be assigned (4) and navigated (5).

Additionally, there is a questionnaire about the exhibition and the usage of technology in a museum setting. There is also a casual game about the semantic relations among the artworks (7).

RESULTS AND DISCUSSION
In order to measure how the interface was used, we developed a logging mechanism to record these interactions. In this way, the actions to access semantic contents and the actions that involve participation mechanisms were recorded. An additional logging mechanism was used to record the number of touches resulting from the interactions with the interface. During 47 days, this mechanism recorded a total of 1,596,639 touches, with an average of 33,971 touches per day. The maximum number of touches per day was 63,928, registered in the last weekend of the exhibition. The minimum number of touches per day was 12,653.

The records of the interactions were performed during the last two weeks of exhibition and allowed to analyze how museum visitors used the application features, as presented below: (1) Access artwork (46%); (2) Access artwork’s details (12.6%); (3) Questionnaire (3.2%); (4) Assign tags (3.3%); (5) Tags navigation (24.4%); (6) Guestbook (6.2%) and (7) Casual Game (4.2%).

The high number of artworks accesses (1) compared with the number of times that other features were used shows that most of artworks accesses were made just for curiosity. The high number of exhibition visitors, as well as the fact that users can manipulate the displayed multimedia objects that represent an artwork, may have caused this effect. The low utilization of the participation mechanisms (3, 4, 6, 7) shows that the average time users spent was relatively low. The second most used features were the Tags navigation (5) and Access artwork’s details (2). As expected, the artworks most frequently accessed are those containing more participation results, i.e., containing more comments.

\(^2\) CCV, http://ccv.nuigroup.com
and larger number of tags assignments.

With the registration of the number of accesses to each artwork, a heat map was built. As shown in Figure 4, the artworks most frequently consulted were closest to the interaction area. However, there is an exception in the artworks displayed in the lower right corner of the interface, away from the interaction area. One reason for this exception may be the fact that those artworks have a strong visual impact for the museum visitors. Other reason may be that the table was deployed relatively close to those artworks. An additional explanation, can be the fact that most users are right handed.

Overall, observing the users, most of them showed a high interest in accessing the artwork’s details, in order to obtain more information. Moreover, some users discussed among themselves the details and the texts related to each artwork. This indicates that users search for further information about the objects they have just seen in the exhibition. The use of these technologies can contribute to increase users interest about the exhibitions.

Some users preferred to manipulate several nodes at the same time using both hands and some played with the artwork objects just for fun, moving them around and watching while they return to their initial position. Several users explored the links between the artworks, without any difficulty regarding the interaction with the device. Some users left the multimedia device due to excessive public cause by the arrival of groups of visitors. However, some users took advantage of the links between the artworks displayed in the lower right corner of the interaction area. However, there is an exception in the artworks most frequently consulted were closest to the artwork, away from the interaction area. One r...

CONCLUSIONS

This paper presented the design process and the issues that need to be considered when building a multi-touch interactive application and physical setup for public spaces, especially museums. The use of this type of devices engages the visitor to further explore the exhibition at a virtual level, allowing to obtain more information and provide feedback. Building upon the experience of this project, the authors intend to continue exploring multi-point interfaces and solutions, in particular, in collaborative situations. The combination of other interaction modalities (e.g., object identification and pen) will also be the subject for further research.

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