Using Tangible Surfaces in Opera

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ABSTRACT

This paper shares lessons learned between the interaction of actors on stage and the computer which we gained in the technical development, rehearsal and performance of the multi-media opera *Amazonas* [1] which were staged in Germany and Brazil in 2010. In particular we focus on the interaction of the actors with a tangible surface (multi-touch table) which offers a broad variety of interaction modalities on stage. We found that the traditional *human-computer-interaction* (HCI) guidelines cannot directly be applied to HCI on stage and therefore investigate and propose a novel HCI paradigm.

Keywords

human-computer-interaction, on stage interaction, art performance, tangible surface, multi-touch, interface design

1. INTRODUCTION

If we want to make contemporary art, then we should break with old traditions and work with the tools of the time. For example opera, which, since Claudio Monteverdi *et al.* established it at the end of the 16th century, incorporating many elements of spoken theatre, such as acting, scenery and costumes and sometimes even dance, has always been a multi-media framework using mainly three different media: images, text and music. Since the days of Monteverdi, however, there has been a tremendous technological development that, in our opinion, is not adequately reflected in the opera or other performing arts such as drama, in particular if it comes to *human-computer-interaction* (HCI). Other areas such as dance and music are significantly less reserved and the use of computer technology is in fact well established there. To point out just a few examples (there are literally hundreds of relevant examples) see work by Laurie Anderson, Bob Wilson from the 80s; La Fura dels Baus, Marcel-li Antunez from the 90s; and Golan Levin, VJing, Laptop Music, from the 2000s. The impact of those interfaces in dance and music is also reflected by the establishment of international conferences such as the conference on *New Interfaces for Musical Expression* (NIME) [2] which was founded in 2001 and is held every year since then.

While traditional HCI applications, using a keyboard, a mouse or a joystick are not attractive to be used on stage as they are hardly (if at all) observable by spectators, several novel HCI methods have been recently developed which are more appropriate for the use on stage. A couple of those novel developments have been well adapted already to music and dance. They include the influence of sound and music by interactive surfaces, including finger gestures or objects, see for example ReacTable [3], or motion using the WII control [6], and it might not take long before we see controller free examples using the Kinect sensor. The use of an interactive surface as a music instrument, such as the just mentioned ReacTable, is more straightforward and clear as its use in an opera. Questions have been addressed about what role the interactive surface should have, how it could be included it into the play or how it will be apprehended by the audience.

Even though it seems to be more difficult to incorporate HCI into opera, theater or drama in comparison to music and dance it is interesting to note that Brenda Laurel has observed in her book "Computers as Theatre" [5] that opera, theater and drama bear some similarities to interface design in a sense that both deal with the representation of action. Thus, a natural link exists between stage interaction and computer interaction. Designing, however, HCI for the interaction on stage varies from the traditional HCI principles in various aspects. The lessons learned, differences and particular aspects which need to be considered are presented in Section 2. We gained those insights within the development process of a large tangible surfaces (display size 192 x 108 cm) to be used in the opera *Amazonas* [1]. Figures 1 and 2 show impressions of this opera.

2. COMPUTER INTERACTION IN OPERA

There are different well-known ways for interaction between humans and computers; e.g. keyboard and mouse, voice control, person, gesture or gaze tracking (3D). In contrast to 'self-used' controllers, the action and system reaction on stage must be obvious to the audience/observer, not necessarily to the user himself. The standard control paradigms, therefore, are not always appropriate to be used in this scenario. For instance mouse and keyboard interaction have a very narrow interaction radius and are therefore not easily visible for the audience. Other methods such as voice control

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Figure 1: Impressions from the opera: scientist (left), businessmen (center) and politician (right) discussing about global warming using touch gestures. The camera view represents a typical audience view.

Figure 2: Impressions from the opera: politician showing places on a map by pointing gestures and physical objects emitting political symbols. The camera view represents a typical audience view.

have the additional drawback that the audience is not aware of the command set and therefore has no clear indication wether an action has been triggered by voice or happened randomly. In addition, besides the obvious examples just given, better established modalities, such as the WII controller, which have been widely used successfully on stage to control visual effects or sound, are not good for our purpose either, as they lack the ability to clearly indicate discrete events. Those discrete events are necessary in our scenario as we clearly have to separate between different scenes. As those discrete events are in general harder to distinguish in 3D by the observer as well as the sensing technology (assuming the right viewing angle in 2D) we decided to restrict ourselves to 2D interaction. In addition, it is easier in 2D to provide feedback directly where the interaction has happened by placing a display right under the interaction surface.[1] Therefore, the reaction can also 'physically' represent the location where the action of the actor has happened, which is easier to observe and to understand by the audience.

To still allow for a lot of flexibility to express oneself by interaction with the computer, the goal was that the tangible surface should provide the following interaction modalities:

- track the position of fingers
- track the position and orientation of objects
- classify objects according to visual labels (fiducial-markers)
- track the position of acoustic events
- classify the acoustic events according to the type of sound; e.g. knocking, brushing, drumming

A brief technical discussion on how to apply these interaction modalities is presented in Section 3.

[1]A nice example of giving feedback in 3D space in the context of an opera was the performance "Der Jude von Malta"where the actors were tracked to allow for mapped projections on the actors white costumes [7]

2.1 Why can the Interaction not be Staged?

Thinking about HCI in the context of an opera the following question might immediately come to mind: "Why is the interaction on the table not staged and played by the actors with predetermined content similarly as done via post-production in movies such as 'Minority Report' or 'Avatar'?". The difference between post-production and a staged opera is that every performance will be different in speed, wording, expression as well as in the reaction from the audience. In the worst case some sections are even skipped by the actors. A strict timeline is therefore not practicable. In addition, some movements would not be precise enough (predetermined or remotely controlled) to look real for the audience; e.g. a zooming gesture with two fingers where the manipulated image on the surface is scaling accordingly to the finger movement of one actor.

2.2 Particular Requirements

In contrast to the general requirements of HCI, additional requirements have to be fulfilled in an opera scenario. In the following subsections a couple of those requirements are introduced and discussed. More details of the individual points follow in the next subsections.

2.2.1 obvious actions

Because the general audience of performing art cannot be assumed to be experts in the field of modern technology and HCI, the interaction must be easily visible and obvious to the naive spectator, not (necessarily) to the actor.

In order to achieve this we restricted the interaction possibilities to the manipulation of virtual, two dimensional[2], objects (a virtual object can include images, buttons, films, sliders, graphs, etc.). Those objects can be interacted with:

- by manipulating physical objects[3] on the surface of the table

[2]a two dimensional object can be directly manipulated on a surface while the manipulation of a three dimensional object needs an additional abstraction step which we wanted to omit

[3]on stage, due to the changing light conditions, those objects

Table 1: Overview of good interaction modalities on tangible surfaces on stage.

interaction	how
switch on/off object	push button, place object
zoom screen in/out	push button
slide	move finger
move object	move finger or object
scale object	two finger gesture
rotate object	two finger gesture
attract objects	by placing an object on the table
repel objects	by placing an object on the table

- by placing fingers on the surface of the table
- by knocking on the table

We found that a couple of interaction modalities on tangible surfaces can be easily understood while others cannot easily be grasped by observers who are not familar with these modalities. Table 1 summarizes the good interaction modalities we found.

2.2.2 *visible actions and reactions from a distance*

In contrast to the interaction by a user where he/she is close to the action taken place, the observer in a theater is further away and therefore interaction gestures are required which can be easily observed from a distance. Additionally, both action and reaction have to be clearly visible for the audience at the same time, which can be either directly or on an additional screen. Good interactions are e.g. manipulation of objects (physical or virtual) or pointing gestures.

2.2.3 *remotely controllable*

In order to allow hints by a souffleur or the interaction of a technician in case of a system malfunction or erroneous interaction with the table by the actors, the system has to be remotely controllable at all time. In addition the remote control of all table functionalities and in particular the possibility to jump into a particular setup of the table, e.g. a particular scene, have been proven to be very useful in the rehearsal phase.

In order to prevent conflicts between the actor and the user of the remote control it is important to block the input for a particular time if one of the two has interacted with the table. This, for example, prevents wrong system behavior by buttons which have been pushed twice, one time by the actor and the second time by the operator. In our scenario, we found that blocking the interaction for two seconds does not disturb interaction (in case two buttons should be pushed one after another) while successfully preventing conflicts.

2.2.4 *dynamic system constrains*

In contrast to a free interaction with a computer system where a short interaction sequence should lead to a particular outcome, we found that in our scenario this freedom of choice is leading to additional interaction errors by the actors and a cognitive overload of the actors. A play has a fixed predetermined order of interaction — within a particular range of freedom — which can be reproduced on the table in order to constrain the possible interactions at a particular point of time or scene. Those limitations, however, have to be selected carefully in order to prevent the audience from observing the interaction as predetermined. We found that different physical objects, which can be placed on the table, can be included in the scene play in a more natural way to separate between different actions than an array of buttons.

could be self-illuminating to be better visible and should have a distinct three dimensional shape to be clearly visible from the perspective of the audience

2.2.5 *fixed system configuration*

While 'traditional' HCI remembers the system state (e.g. the window position, etc.) in our scenario the system state should not be remembered but instead the system should always return to a set of predefined settings. This is particularly important as the actors learn a specific series of actions to be reproduced on stage and are therefore not able to react to a changed setting - as opposed to what a 'normal' user would do. The fixed interaction is not only important for the content on screen, but also for the physical objects in their rest position (as marked by small stickers on top of the objects showing the same symbols as on the objects themselves), as demonstrated in Figure 3.

Figure 3: Physical objects, their respective rest position and one object on the table which attracts floating images on the table surface.

2.2.6 *on the fly customization*

In order to react — in real time — to the requirements of the stage director during the rehearsals, it is important that the system setup can be changed without long delays; e.g. without rebooting the system or restarting the program.

3. TECHNICAL DETAILS

In this section we briefly describe the technical developments to realize a tangible computer interfaces to be used in operas. A good general overview on how to build a multitouch table, based on visual tracking, can be found in [9]. Here we focus on some of our particular requirements.

3.1 XML Setup

The visualization, interaction and system logic have been realized by means of our own software development, using C++ and OpenGL besides other software and libraries. Acoustic events are played using the "Klangdom"[8], an audio spatialization instrument developed at the Institute for Music and Acoustics at the ZKM, driving the 26 audio channels of the system.

To allow for an on the fly customization of the visualization, interaction and system logic, we have developed a simple XML framework[4], where objects, buttons, sliders, images, etc. can be added, changed or removed by editing a setup file.

3.2 Remotely Controllable

Besides the software of the table we had to develop a remote control which reflects the status of the table and is able to send control commands to the table. In order to keep the control simple only those objects and buttons have been shown which are currently displayed on the table. In addition the changes in the XML Setup should also be immediately reflected in the remote control to reduce the time to change the setup and to prevent mismatch between the setup of the remote control and the setup on the table. We have, therefore, designed the remote control such that all active objects and possible interactions are sent from the table to the remote control instead of relying on a second setup file.

3.3 Visual Classification and Localization

For visual tracking we have relied on the reacTIVision toolkit provided by Martin Kaltenbrunner and Ross Bencina [4]. In our scenario the toolkit provided a very robust tracking of physical objects, also in changing light conditions, while the finger tracking was not particular robust. To increase the robustness of the finger tracking the actors had to wear a black tape wrapped around the finger approximately one centimeter behind the fingertip.

3.4 Audio Classification and Localization

To not be restricted to slow events such as a moving finger or object on a tangible surface, but also be able to react to fast events such as knocks which are particular useful to express strong emotions, we added acoustic event detection. Those fast events could otherwise not be detected as cameras (typically) work with a frame rate of a maximum of 60 frames a second.

4. CONCLUSIONS

The introduction of a tangible surface and the interaction with it by the actors have provided novel ways of interaction on stage and the possibility to present information within the opera in a natural form, as the interactive display is integrated in the play. We have presented our lessons learned by developing and using such a devise in the *Amazonas* opera which were staged in Germany and Brazil in 2010.

[4]It has been used, besides the opera, in a workshop about tangible interfaces at the University of Art and Design, Karlsruhe.

5. ACKNOWLEDGMENTS

We would like to thank the following institutes for their support to realize this ambitious project: Goethe-Institut, Münchner Biennale (Germany), ZKM | Karlsruhe (Germany), SESC São Paulo (Brazil), Hutukara Associação Yanomami (Brazil), Teatro Nacional de São Carlos (Portugal).

The cooperation partners: Operadays Rotterdam, Netzzeit (Austria), the *Culture* programme by the European Union, Petrobras, Deutsche Bank, Fundaçao EDP.

The official media partners: ARTE, Deutschlandradio Kultur, Antena 2 und RTP.

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