DiamondTheater: A System for Reproducing Theater and Supporting Creative Activities

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Abstract. This paper describes a system called DiamondTheater that supports creative activities in theater using a tabletop tangible interface. This system is used to aid in the planning of certain aspects of theater production, such as actor positioning, and sound and lighting cues. Without having some considerable experience in production, it is difficult to create a mental picture of an actual production. Thus, a miniature theatrical stage is reproduced on the tabletop surface to facilitate the user's creation of such a picture and the sharing of ideas. Users collaboratively construct a stage by placing small dolls to represent actors and many kinds of miniature stage sets. In addition, the system allows users to reproduce other aspects of theater production such as sound and lighting. We performed a user study of this system and demonstrated that DiamondTheater appears to effectively assist the user's activity in theater production design.

Keywords: collaborative work, theater, tabletop tangible interfaces.

1 Introduction

Theater is the branch of the performing arts that involves acting out stories before an audience. Theater is often created by utilizing a variety of elements, including speech, gesture, dance, and sound, and it has come to take on many forms by combining these elements. One type of stagecraft for theater takes a technical point of view, and encompasses, for example, lighting, sound coordination, and spatial design. A central issue in the process of designing theater productions is that it is not easy to work while maintaining a comprehensive mental picture of the entire production. Although this would not be so difficult for a person who some considerable experience, it is not easy for someone who is less experienced.

In recent years, many researchers have developed a variety of systems using tabletop interactions and tangible interfaces[1,2]. These systems based on tangible interactions employ physical objects as user interface elements to represent and control the computational process. Operations that are based on both tabletop and tangible interactions are more instinctive and familiar for users than GUI interactions.

Our system, called DiamondTheater, builds on a series of tabletop tangible interfaces to support face-to-face collaborative work. DiamondTheater focuses particularly

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on the process of designing and arranging theater productions for actual public performance. By constructing a miniature theatrical stage on a tabletop surface, DiamondTheater helps users imagine and design theater productions, assisting with aspects of theatrical productions such as lighting and sound, as well as the interplay between actors and other theatrical elements. Each user can work while sharing the entire image of the production with the other users.

2 Creative Activity in Theater

Theater as an artistic production is a branch of the performing arts and is usually created by utilizing a combination of diverse elements, such as stage lighting, sound effects, special effects, and stage sets. Staff members work according to their roles. A general example of a work flow in theater leading up to a public performance is shown in Figure 1. The cue sheet in Figure 1 is a form or template that lists information about cues. A theatrical cue is the trigger for an action to be carried out at a specific time. An action could be, for example, a lighting or sound change. Usually information about execution, timing, sequence, and details of the production are also written on the cue sheet. The board operators and running crews operate the theater productions they are involved in during a performance while confirming the information written on the cue sheet dealing with their department.

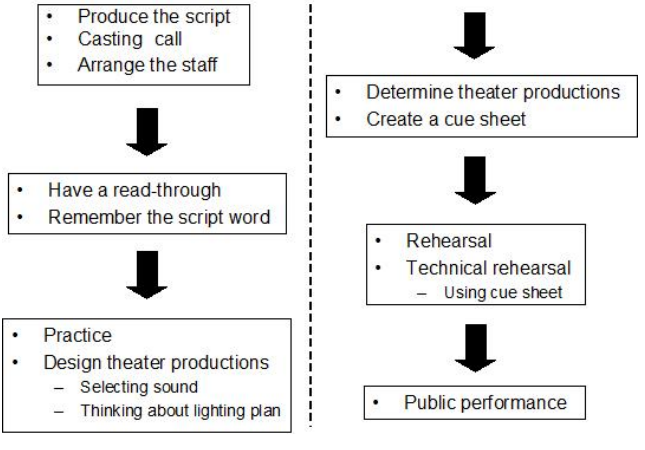

Fig. 1. A simple example of the work process leading up to a public performance

3 Related Work

Many researchers have studied systems that support a wide variety of creative activities, such as story creation, animation and drawing[3,4]. Although many systems supporting two-dimensional creative activities have been studied frequently, systems for three-dimensional creative activities, such as a dance and theater, have not been developed well. Little is known about systems to support activities for these branches

of the performing arts. Several researchers have developed systems for theater activities, almost all of which use computer graphics and virtual spaces to represent the theater stage[5,6]. These systems using virtual spaces help users imagine the actual stage used in theater. However, virtual images are somewhat lacking in their ability to represent reality.

Moreover, these systems help users to understand basic theatrical concepts, but are not systems that can be used to support real-life work. Of the few systems that support real-life staff works activities in theater, Avatar[7] is an application for supporting the distributed collaborative production of theater shows. The authors use virtual reality to represent certain theater scenes. When designers cannot actually be co-located to collaborate with each other on the design, Avatar displays the virtual scene using computer vision at the remote locations to share the scene in real-time. In Avatar, small objects with AR markers are used as input devices to the virtual world that is being shared by remote directors who are participating in the design. The poses and positions of the objects are recognized by using a webcam to observe the markers. This idea would be useful to facilitate the collaboration of remote users in production design. However, it is probably better to use real mockups in the case of co-located collaboration because the designers can share the workspace.

There are many commercially produced systems for designing theater productions.

For example, Matrix3[8] is a system for audio show control, and wysiwyg[9] is used to plan, design, and program lighting productions. These systems assist user's theater production design; however, users who are inexperienced in theater would be not able to operate these systems effectively since almost all such systems are tools for professionals. Moreover, the interfaces of these systems are usually PC-based and use a GUI, and these are normally systems for personal use for that reason. Thus, such systems are not assumed to be used by multiple users.

We are interested in a system that can support the real-life work of staff, especially co-located collaboration in theater. We focus on the pre-production process of theater regarding theater production design. When compared with people that have a wide range of experience, it is difficult for staff without much experience to picture the actual stage, which includes a wide variety of theater elements such as sound and lighting, when thinking about theater productions. Furthermore, a cue sheet is created after the discussion of the theater production, but it is very complicated to write out a cue sheet by hand or using a PC based on the theater productions that were decided regardless of whether the person has experience or not.

4 System Design

Our objective is to use our system to solve some of the above-mentioned problems.

The major objectives of our system are (1) to help users create a mental picture of the actual stage when designing and considering a plan for theater productions, (2) to provide users with opportunities to share the ideas of each user, and (3) to reduce the amount of effort required to create a cue sheet.

This system helps users visualize the actual stage and theater productions. Users can collaboratively discuss the theater productions for actual live performance using this system. The interface is based on an interactive tabletop surface, on top of which users can reproduce a small stage. Our system uses MERL's DiamondTouch table[10]

to support face-to-face collaborative work, and allows users to collaboratively design theater productions while sharing ideas. Users can also easily reproduce theater productions that they conceive, such as lighting and sound, on the reproduced stage, and easily confirm the relationship between the actors and other elements. Because the theatrical stage is represented three-dimensionally on the DiamondTouch surface, it is easier to capture the entire image of the actual stage, including depth and height, than when using theaters with virtual spaces.[5,6,7]

The theater production data that users design and finalize is saved as electronic data in an XML (Extensible Markup Language) file. A cue sheet is automatically created based on the theater production data, and the users can obtain cue sheets as needed. As a result, the system saves users the trouble of making cue sheets.

At the present stage we intend for our system to be used by people who are inexperienced in theater, such as children and students. It is difficult for inexperienced people to design theater productions while comprehensively creating a mental picture of them. We believe that our approach is an effective way for such people to enhance their creativity and to support creative activities in theater.

5 Implementation

5.1 Overview and Architecture

A system image of DiamondTheater is shown in Figure 2. This system consists of two types of displays: DiamondTouch for reproducing theater productions and the stage, and a semi-transmissive display for showing information about the script and theater productions that the user has selected.

We represent a theatrical stage on top of the DiamondTouch table. This is placed on a large rack, as shown in Figure 2. Placing a doll as a surrogate for an actor and placing small stage sets, the system reproduces a stage on the surface as shown in Figure 2. Specific graphics are drawn on the tabletop using an overhead video projector. The stage and theater productions are graphically projected onto the table from above as shown in Figure 3. The DiamondTouch senses the position and movement of the dolls placed on the tabletop surface.

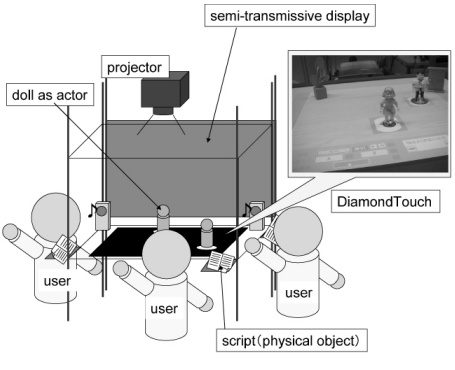

Fig. 2. System image in which users are thinking about the production collaboratively

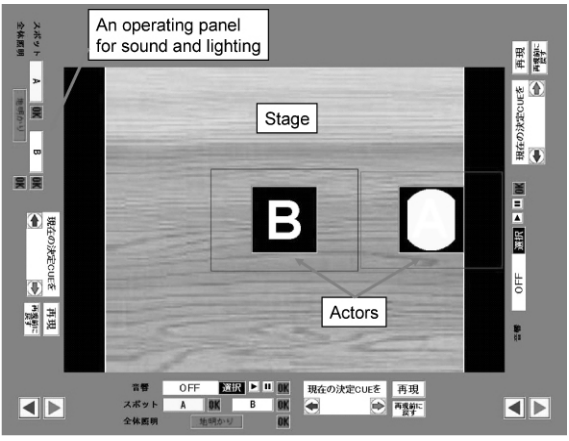

Fig. 3. An operating panel and a theatrical stage projected onto the tabletop surface

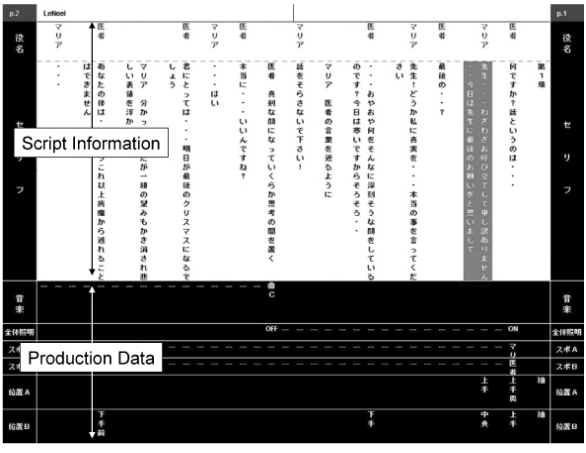

Fig. 4. Production and columnar writing script (Japanese style) data projected onto a semi-transmissive display

The DiamondTouch can identify the manipulator by recognizing an electric signal that is transmitted through users when they touch the DiamondTouch surface. Then we add a round metal plate to the bottom of each doll and wrap a copper wire around the doll to enable it to be recognized by the system. Using the metal bases enables the electric signal to be carried from the user's body through the metal and wire to the table. When the users place a doll on the tabletop surface, the metal and wire carries the electric signal from the user to the DiamondTouch, and the DiamondTouch recognizes the signal and identifies the manipulators. Moreover, in order to assess the differences among the dolls, we add different-sized metal plates at the bottom of each doll. Therefore, by calculating the size of the metal plate placed on the tabletop surface, the system can recognize which objects the user is manipulating. As a result, the system can distinguish between the positions to which the user may move an object

without the use of any tools other than the DiamondTouch table. If metal plates of different sizes are added to the dolls used, the system can theoretically distinguish between any numbers of dolls.

The semi-transmissive display is used to display various additional information. This display is placed upright beside the rack as shown in Figure 2. A sample image of this display is shown in Figure 4. The semi-transmissive display shows data about the theater productions and script information. The data about the theater production that users have decided on at the time of using the tabletop appear at the bottom of the screen. Script information, such as the lines, stage direction, speakers, and page numbers, appear at the top of the screen. These data are projected onto the semi-transmissive display from the rear projector.

Users can use a script (tangible object) that is actually used in practice. Instant memos and ideas are often written into scripts during practice or during discussions between staff. These actions are important to support the staff's creative activities, and it is for that reason we use a real script. We use RFID technology to load data about the script into the system. We add RFID tags to the pages of the script to be able to identify particular pages when they are viewed. When the page of a real script is turned over, the RFID reader attached to the rack loads the data and reflects the information of the selected page and projects it onto the semi-transmissive display.

5.2 Operation Procedure

Users mainly take three steps to determine theater productions with DiamondTheater: (1) Choose line or stage direction to coordinate the theater production, (2) design the theater production while actually reproducing it using the system, and (3) finalize and save the theater production.

Users first select a line at which they want to think about the theater production.

Using RFID technology, DiamondTheater can identify which page of the script the users are looking at. Every time a page is turned over by the users, the tag data is recognized by the RFID reader, and information about the script on the page is read.

The system provides users with a button to select a particular line on the tabletop surface. Users can select a line simply by touching this button while watching the data shown on the semi-transmissive display.

Users design the theater productions while reproducing them and participating in collaborative discussions. Each theater production can be determined in association with a single or multiple lines/stage directions.

The results of the theater productions that have been designed are saved as electronic data in an XML file. If a user requires a cue sheet, it can be automatically and easily output using DiamondTheater functionality without the need for complicated work.

5.3 Reproduction of Theater Productions

The system can reproduce three kinds of stage effects: one of sound and two of lighting. The two types of lighting that can be reproduced are global lighting (border light) and spotlight. The look of turning a spotlight onto a doll instead of an actor is shown

in Figure 5. Each lighting effect can be turned on or off using a simple interaction with the system. Therefore, by simply touching a finger to the tabletop surface, users can control the lighting. In addition, sound is also available via a simple interaction. When a user selects by touch a piece of music that he or she wants to play, the music will play from two separate speakers placed near the tabletop.

The standing position of an actor on stage is represented using a small doll. An example of the dolls used is shown in Figure 5. The system can recognize the actor's position if a user places a doll on the tabletop surface. Based on the position that the user places the doll, an image which expresses the actor's position is graphically projected on the tabletop (A or B shown in Figure 3). The users consider and determine the actor's position. Then, when the doll is quickly touched twice to the tabletop surface at the designated position, the position data is determined and saved in an XML file.

Fig. 5. A spotlight turned on a doll used to represent an actor

5.4 Use of Production Data

We have defined a new language to save it, called CueML (Cue sheet Markup Language), which is based on XML. CueML is the language used to save data about the theater productions and to produce the cue sheet. The data for each production is saved and related to a single or multiple line(s)/stage direction(s). A cue sheet for reference during the actual performance is automatically produced by the system using the CueML data.

A variety of XML elements are defined using XML tags in CueML. We can save more detailed information of a theater production in addition to the data that can be saved using the current implementation of DiamondTheater. For example, we can save data regarding volume and a sound effect, intensity and color for lighting, and so on. The current version of DiamondTheater cannot, however, deal with such detailed information. However, we will be able to extend the functionality of DiamondTheater to include these functions in the future.

The system allows users to refer to theater productions that other groups saved previously by reading in data from a previous or current CueML file. This allows users to design theater productions by referencing other ideas. This process will support users in getting new ideas when users come to a deadlock.

6 User Study

6.1 Overview

We conducted a user study to clarify the effects of DiamondTheater on users. The objective of this study was to observe how the system would affect the users' theater production planning, and how users would interact with the system. Fourteen university participants aged 21 to 24 years were asked to participate in this experiment. The participants worked in pairs during the experiment. All of the participants were inexperienced in regards to theater activity, and were novice users of the interface that we developed. Participants were asked to freely and collaboratively design theater productions about a script that we prepared using the interface. We used another interface using a PC in order to compare DiamondTheater to a system without DiamondTheater. The participants received an explanation of how to use each system before starting the experiment. A script that we produced for two-page spread was used for this experiment. The participants were asked to decide on three types of theater productions without a time restriction using each system and the script. The three types were sound, lighting, and actor positioning. The experiment had the following two system setups: DiamondTheater, and a PC and dolls.

- DiamondTheater: Participants were provided with two dolls associated with actors. The positions of these dolls when placed on tabletop surface were automatically identified by DiamondTheater. The user received an explanation of how to control and turn on and off the sound and stage lighting. After designing the theater productions, the participants were asked to save their data.
- PC and dolls: This case was similar to the work usually undertaken by theater production staff. The sound was played using a PC. However, stage lighting was not available because it cannot be easily reproduced in the normal environment. Participants were provided with two dolls to help them create a mental picture of their idea, the same as was done with the DiamondTheater-based system. Participants were asked to write the results of their designs on the script by hand.
- We wanted to understand how DiamondTheater would allow participants inexperienced in theater to create a mental picture of their actual theater productions. We observed the user interaction in each setup, and analyzed whether DiamondTheater supported user activities related to theater production design even if the users had little or no experience in theater. After designing theater productions, we asked participants whether they noticed any particular aspects of the system.

6.2 Results

Through this experiment, we were able to confirm some practical advantages of DiamondTheater in the process of planning theater productions. Participants seemed to actively interact with DiamondTheater while communicating with each other. With both system setups, participants designed a theater production freely with their own ideas while showing each other their ideas.

The considerable difference between the two setups was the number of interactions with each system. Participants clearly interacted with DiamondTheater more actively

compared to the setup using a PC and dolls. DiamondTheater was likely a more familiar and intuitive interface than the PC and dolls setup. The participants were able to use the system easily by touching the tabletop screen or using physical objects (dolls and a script). Therefore, the participants were able to quickly become accustomed to the operations when using DiamondTheater. With DiamondTheater, almost all of the participants proactively tried to reproduce their ideas for the theater productions as they came up with them. As a result, the participants could design theater productions and share specific images while having an actual mental picture of their ideas.

On the other hand, participants often thought about the three kinds of theater productions separately when using the setup using a PC and dolls. Although the participants were able to confirm the sound and actor positions, reproducing the stage lighting was normally difficult. Participants were not able to create a comprehensive mental picture of their production idea due to this constraint. This is a problem that could possibly occur in the process of actually designing a theater production.

In addition, when using the PC and dolls setup, the participants sometimes selected incorrect productions for certain scenes. We define an incorrect production as incongruous or not appropriate for a certain scene. For example:

- All lighting is turned off when there are lines of dialog.
- Only one spotlight is turned on when two actors are talking.
- The distance between the standing positions of the actors is too distant when they are talking with each other.

We counted the number of incorrect productions in each single line or stage direction based on the theater production data collected from participants. Therefore, if an incorrect production occurred for three consecutive lines, the number was three. As a result, we found only one incorrect production when the DiamondTheater setup was used. However, nine incorrect productions were found when the PC and dolls setup was used. Incorrect productions increased dramatically when DiamondTheater was not used.

All of the incorrect productions were found to concern stage lighting. Incorrect productions occurred at stage direction (for example, "He said it with a grim expression"), where participants decided on theater productions without a light turned on the actor in such situations. If all of the lighting were turned off, the audience would be not able to know what the actor's expression was.

The number of incorrect productions was dramatically reduced when using DiamondTheater than when not. This result suggests that DiamondTheater adequately supported the participant's activities. Judging from the experiment, the participants worked while actually confirming their ideas with DiamondTheater. This is why the participants would seem to be able to accurately understand the situation of the theater productions that they were thinking about. However, with the setup using the PC and dolls, the participants were not able to adequately create a mental picture of their production ideas, especially in regards to stage lighting. This is because the participants could not try out their lighting plans with such a system, which was not the case with DiamondTheater.

7 Conclusion

In this paper, we have presented a system called DiamondTheater. This system in its current form is for use by people who are inexperienced in theater. DiamondTheater provides users with the opportunity to reproduce productions on a miniature theatrical stage. With the ability to reproduce various productions as well as an actual theatrical stage, users can design productions efficiently with a clear image of the production and collaborate when conceiving ideas. Participants in our user study were more successful and efficient when using DiamondTheater at design tasks in spite of their lack of experience. Thus, DiamondTheater allows users to use free-thinking when working in order to develop good ideas for diverse theater productions, and supports real-life creative work activities using simple operations.

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