Design of an Interactive System for Immersive Movie Watching Experience

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***Abstract*—As new technologies for creating digital contents are developing, more and more innovations about reading and listening are emerging. In film making, simple visual and auditory effects may not satisfy the audience any more. Besides, as home entertainment systems are becoming more popular, people see a movie not only in the theater but also at home. In this work, we present an interactive film watching system allowing a viewer to move her body in an intuitive way to change the viewing angle of the film as well as the development of the story. The system aims at using ingenious content design and immersive interaction to enhance user's viewing experience. A regular computer with a webcam is used to detect the position of the user, which is then used to control the viewing angle of the video taken through a fish-eye lens. At some specific point in the story plot, different viewing angles would automatically determine the selection of different story branches, which can greatly increase the replay value of an interactive story. We have conducted an experiment to study the effectiveness of the system. Ten users were invited to experience our system. The evaluation result shows that most users agreed with the design idea and enjoyed the new viewing experience. We believe that the system provides a new way of communication between the storyteller/director and the audience. We hope that this preliminary work can shed some lights on the future development of video-based interactive storytelling.**

Keywords- Movie Space; Immersive Experience; Human-computer Interaction.

I. INTRODUCTION

With the development of new multimedia technologies, "audience" behaviors are no longer limited by the traditional audio and video environments in the past. For example, simple visual and audial effects in a traditional theater cannot satisfy the audiences any more. Therefore, the design of wider surround screen, such as the Image MAXimum (IMAX) screen and devices to stimulate multiple senses (such as movement and smell) has emerged to bring the audience's experience to a next higher level.

On the other hand, due to the increased network bandwidth at home and the price drop of home entertainment systems, more and more people choose to watch a movie at home on a TV or on a computer [18]. Nevertheless, the watching experience at home is still not comparable with the one in a high-end theater because of the small watching screen. The dark environment in a theater helps the audience focus on the film, and the wide screen also makes people immerse into the scene more easily. Instead of changing the equipment and environment at home, in this research, we propose to design an interactive video watching system on a regular computer with contents of greater interactivity to enhance the immersion experience of an audience when she watches a movie on a small screen.

Persson thought that interaction was the main difference between movie and digital space. That is, screen can become an interactive interface instead of a simple projection surface [12]. Recently, the meaning and definition of audience started to receive new attentions [10]. The discussions about subjectivity of a film have changed the definition and behavior model of an audience. The transfer of authorship has made a passive audience become an active participant. The subjectivity of a film now includes the participation of the viewer.

Based on such a motivation, we hope to release the limitation on the traditional imaginations about film [11]. We hope to allow the audience to view the film in an intuitive and interactive way such that the whole information of the film can be acquired through active interactions. With such a system, we cannot only create a new way to watch films, but also deliver deeper meaning through user participation.

Therefore, the main objectives of this research include:

(1) Implementing a good interactive mode to provide a narrative framework allowing a user to immerse in the film-watching experience.
(2) Using computer vision techniques to see if the human-computer interaction can enhance the viewing experience and provide better enjoyment about the story.
(3) Investigating how screen and space can be used together in digital media for storytelling and learning what kind of story could be more appropriate.

The rest of the paper is organized as follows. In the next section, we will review the work pertaining to this research. In Section III, we will describe the design and implementation details of our system. In Section IV, we will present the experiment that we have conducted to evaluate our system, and in Section V, we will analyze the results obtained in the experiment. In the last two sections, we will present the possible future extensions as well as the conclusion of the paper.

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Figure 1. Illustration of the proposed interactive system. Screen is like a window, through which the world is observed.

II. RELATED WORK

Our work pertains to previous research in immersive experience, content presentation in 'Movie Space', and Human-Computer Interactions (HCI) research on natural user interface.

A. Immersive Experience

Csikszentmihalyi was the first one to propose the theory of immersion. He regarded a person to be in an "immersion" state when he focused on the activities of a given scene by filtering out irrelevant noises [2][3]. Later researchers further remarked on the definition and considered immersion as the state when a user concentrated on the activity and enjoyed the process.

Trevino and Webster extended Csikszentmihalyi's work to consumer navigation on a digital system and proposed four properties in the state of immersion: [15]

(1) **Control:** Individuals experienced the feeling of control not only on himself but also the interactions between human and computer.
(2) **Attention Focus:** Attention was focused on an involving activity. An individual's focus can be narrowed down by filtering out irrelevant thoughts and stimuli.
(3) **Curiosity:** During the immersive state, an individual's sensory or cognitive curiosity can be aroused.
(4) **Intrinsic Interest:** Individuals were involved in an activity for the pleasure and enjoyment it provided instead of for instrumental purposes only.

Additionally, Hoffman and Novak thought that telepresence and interactivity were important because they could increase immersive experience [7].

(1) **Interactivity:** Interactivity is about the cycling process of multiple users performing listening, thinking, and speaking. Daniels regarded an Exemplary Viewer as an active participant in addition to passive viewer [4]. Webster et al. indicated that immersion emerged through interaction with the computer [15]. Johnson and Wiles also pointed out that controllability in a game brings positive affective experience [9].
(2) **Telepresence:** Presence is "the natural perception of an environment," and telepresence is "the mediated perception of an environment [5]." The more controllability on one's movement and viewpoint, the more degree of presence [19]. In addition, it was reported that the sense of presence also elicited the feelings of a user [13].

B. Movie Space

Movie space can be divided into 'on-screen space' and 'off-screen space' [1]. On-screen space can be simply defined as all you can see on the screen while off-screen space is more complicated because it allows a user to interact with the objects outside the screen and allows them to suddenly enter the screen to deliver some special meaning. The camera often represents the opinion of a narrator, and a shot is a way to deliver emotions to the audience. The techniques of shooting and camera movement, especially the composition of a shot, affect our perception of the narration in the story. Our system attempts to break the boundary between the off-screen and on-screen spaces and solves the aspect-ratio problem when a movie is displayed on a different screen.

C. Natural User Interface

The definitions between 'Natural User Interface' and 'Tangible User Interface' are often confused. A good way to distinguish the two could be on if the user is able to forget the existence of the interaction device after the user becomes familiar with it. In other words, a natural user interface becomes invisible to the user to a certain extent. An excellent interface design should allow a user to seamlessly move between the physical and virtual spaces without feeling the existence of the technologies [6][8]. For example, when a video camera is used in a system to perform image capturing and analysis, a user of such a system may often forget the existence of the camera and concentrate on the screen after some time of practice. This kind of interface can facilitate the sense of telepresence and immersion in a virtual environment.

Most of the previous interactive storytelling systems focused on the automatic generation of story contents based on user mouse selection and texts or speech inputs [14]. However, these types of interactions usually required a user to use a different modality other than simply viewing. Consequently, the switches of modality often affected the flow of viewing, which was the main modality in film watching [17]. Therefore, in this work, we hope that navigation in a digital space can be incorporated with the narrative of a film such that the enjoyment of film watching can be enhanced based on the interaction of the system.

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III. System Design and Implementation

In this section, we will describe how the interactive mode for the immersive viewing experience is designed, what kinds of technologies have been used to facilitate the design, and how the movie is produced.

A. Interactive design

We hope that a user moves her body in a natural way to change her view angle interactively and to make a decision on how the story is branched. In other words, we hope that the development of the story, which was originally controlled by the director, can be partially returned to the audience with the aim of enhancing the recognition of the story by the users.

We view the computer screen as a window and the film content is what happens outside the window. From different viewing angles, one can see different parts of the world, as illustrated in Figure 1. The spaces inside and outside the window frame can then be blurred and merged. Traditional meaning of a shot through framing can be extended through interaction.

Another important factor in such a system lies on the clever design of the content such that the scene inside the window is not complete and the actors move through the boundary of the frame. The design of the layout, viewing or moving directions of the actors, and the sound effects also play an important role in enhancing the sense of suspense to trigger the curiosity and peeping desire of the user for them to move their bodies to explore the space.

Besides moving the body to change the viewing angle, at some branching point of the plot in interactive storytelling, the user can also use the viewing angle to select a specific branch, which is accomplished by attaching a separated film fragment that is deliberately designed for seamless transition. Consequently, a user may see different story plots at different runs, which increase the replay value of a film.

B. Hardware and Software

A computer with a webcam is the only required equipment in our system. We use computer vision technologies to detect the position of the viewer, and through the detected position, we interactively change the viewing angle of the film. Compared to tangible equipment and surround virtual environments, such as 3D CAVE, interacting with a web cam is not only cost effective but also intuitive. Nevertheless, the extent of the changes that can be made is somewhat limited.

In our system, we have adopted a web-based approach with HTML5 technologies to increase the accessibility of the system. The image of the user captured through the web cam is acquired from the getUserMedia API and analyzed by the open source package, called clmtrackr , released by MIT. In this package, a user's face is detected, and its position is determined to select an appropriate streaming video fragment to display on a 3D plane implemented in WebGL [16]. The plane is then moved according to the detected face position of the user, as shown in Figure 2. In order to mimic the viewing effect of a human eye, we have implemented a nonlinear mapping between the viewing direction and the field of view. When the viewing direction is farther away from the central direction, the field of view also becomes wider. In addition, we have designed a light-weight test interface at the upper right corner of the screen, as shown in Figure 3, to check the face detection and system settings, and this interface can be hidden when the experiment is conducted.

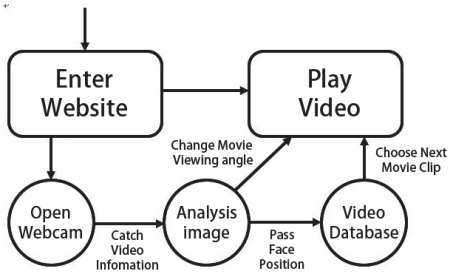

Figure 2. System flowchart

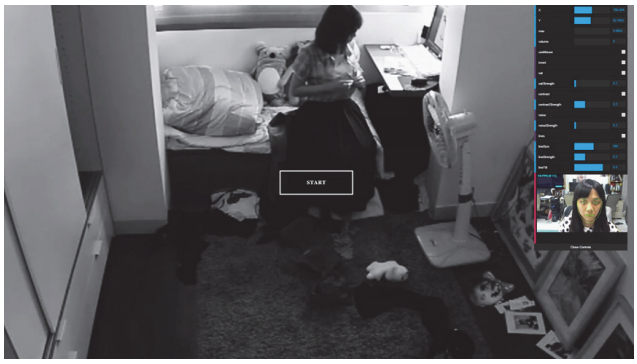

Figure 3. A screenshot with the system diagnosis tool displayed.

C. Movie Production

The video used in the main experiment is five minute long, and the style is suspense. In addition to the main plot line, there are two branches in the story that can be used as a result of user interaction. This design of interactive narratives is to increase the replay value of the film such that a user has a higher motivation to watch the film repeatedly. In most of the footages in the film, we have used long shots to allow the users to have more time to digest the contents on the screen.

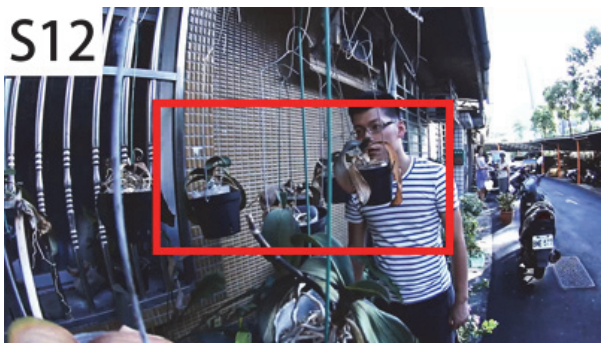

Figure 4. Sample footage taken through a fisheye lens.

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In the composition of the shots, we have tried to connect the on-screen and off-screen spaces to increase the possibility of communication between the film and the user. In order to facilitate the production of the film for a wider viewing angle, we have used a fish-eye lens to take the shots and adjusted distorted region of the shot through a post-production. As shown in Figure 4, the red rectangle is the initial view window and can be moved to a different position through user interaction.

IV. EVALUATION

To understand the feasibility of our interactive mode design and user experience, we have designed a series of steps in our experiment as shown in Figure 5.

Figure 5. Experimental process diagram.

A. Experimental Subjects and Location

In order to understand the immersion of users during the interactive film viewing process, we have conducted experiments with ten subjects. These users were selected by a pretest survey about their film watching habits, such as the frequency of viewing a film at home and in a theater, to ensure that the subjects have a good span of user diversity.

In order to create a film watching atmosphere at home while controlling the experimental settings, we have conducted our experiments in a research laboratory as shown in Figure 6. The laboratory is decorated like a living environment such that the experiments can be conducted without disturbance and the participants can feel relaxed. In addition, the researchers can observe and analyze the behaviors of the participants through one-way mirror and a high-resolution video recording device.

Figure 6. Pictures comparing the behaviors of different participants in the interactive film viewing experiment.

B. Experimental Process

In the first step of the process, we gave the participants an instruction describing the experimental process in order to help them understand the purpose and operational notes.

Before the formal experiments were started, we showed the participants a short film and allowed them to practice how to interact with the system by moving their bodies. When a participant felt confident about the interaction, she could initiate the formal experiment by herself. During the film viewing process, the researchers observed the participant's behavior in a control room and recorded the whole session for further analysis. When the film ended, there was a "replay" button on the screen to allow the participant to watch the film again. The participants can watch the film as many times as they want.

After the participants finished watching the film, a survey and interview session followed. The interview started with some pre-defined questions and was then followed by open discussions to understand their experience and suggestions.

C. Questionnaire Design

According to the reference and research purpose, we put together the elements related to immersive experience. We have used 'The Antecedent of Immersion' by Hoffman and Novak and 'The Features in the Immersive State' by Trevino and Webster to design the main schema of our questionnaire in the Likert 5-point scale (from 1 for "totally disagree" to 5 for "totally agree"). The means and standard deviations of the scores for these questions were then calculated for further analysis.

V. EXPERIMENTAL RESULT AND ANALYSIS

The user feedbacks are divided into two parts: content analysis and immersive experience.

A. Content Analysis

Most participants agree that the designs of actor's sight (Figure 7), actor movement (Figure 8), cropped screen (Figure 9), and scene (Figure 10) affect a viewer's behavior in watching the video.

Figure 7. Character's sight may be used to catch a viewer's eyes.

Figure 8. A character moves from the on-screen space to the off-screen space.

Figure 9. The cropped video invites the viewer to change the view angle.

As shown in Figure 10, a T-junction was used in a scene where the character tracked someone but got lost. He could turn left or right. If the user looks toward to left side, he will meet a stranger; otherwise, he will find a dumped garbage bag. In addition, the less complete a shot is, the more desire a user may have for moving her body. However, the information in a shot cannot be too diverse such that the focus of what the director would like to show is lost. Furthermore, in the shot used for branch selection, it is important to give the user a strong motivation (e.g. with life threat events) to move her body and look around.

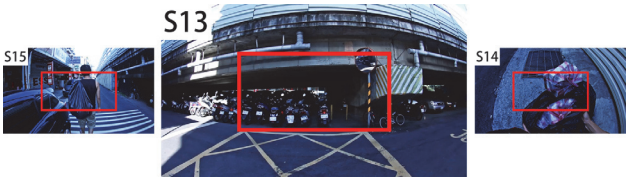

Figure 10. Scene design for different story development

B. *Immersive Experience Analysis*

In this section, we will analyze the questionnaire in two groups: 'The Antecedent of Immersion' and 'Properties in the Immersive State.' According to the experimental data, we have also conducted in-depth interviews with the users to acquire their feedbacks behind the questionnaire.

TABLE I. THE ANTECEDENTS FOR ENTERING THE IMMERSION STATE.

	Question	avg.
Interactivity	There is no need to spend too much time to get familiar with the system.	4.5
	The interactivity of this system is interesting.	4.5
	The interactivity of this system is intuitive.	4.1
	The mode of operation of this system is smooth.	3.5
	Every shot design make me want to move my body to see the outer part.	4.8
	Every time the screen through my options is different, it makes me feel surprised.	4
Telepresence	I think that the viewport is like my eyes.	4
	Sometimes I feel myself in the scene when I watching the movie.	3.3
	Sometimes I think that I am one of the characters in the story when I watching the movie.	2.8

As shown in Table I, in the interactivity section of the antecedent conditions for immersion, most users consider our system as intuitive, interesting, and easy to understand. However, the user may get tired after some time of engagement. It is suggested that the vertical movement may be replaced by leaning forward or backward for zooming in and out.

In the section of telepresence, the scores we get are lower than the ones in the other section (especially for question #9). Some of the subjects consider that the window frame indeed may prevent them from entering the state of immersion. However, we think this may be improved by adopting more first-person shots in the cinematographic design.

TABLE II. THE FEATURE METRICS IN THE IMMERSIVE STATE.

	Question	avg.
Control	10. I feel that I can freely manipulate the system.	3.8
Attention Focus	11. My perception of the external environment will be reduced when I watching the movie.	4.2
	12. Compared with watching movie on the radetional computer, the system made me focus on more the details on the screen.	4.3
	13. Compared with watching movie on the radetional computer, the system put me in more the story.	3.8
Curiosity	14. The interaction of the system will deepen my curiosity about the movie.	4.6
	15. It satisfy my desire to watch movie by watching the outer side of the screen.	4.4
Intrinsic Interest	16. The system made me want to watch the movie again and again.	4.3
	17. Compared with watching movie on the traditional computer, the system gave me more fun.	4.3

In the section of features metrics for the immersive state as shown in Table II, we have received some unexpected interesting feedbacks. For a same shot, users of different personalities or genders may pay attention to different objects or places. For example, a female subject may pay attention to the layout of a male actor's room. This demonstrates the importance of allowing a user to have control since they may choose a different view point when interacting with the film.

However, in content design, it is still important to retain the property of storytelling and get a balance between interaction design and content creation since it is, nevertheless, a film instead of a game. In addition, sound tracks are as important as visual images since sound can attract the attention of a user on the screen. It could be even a better idea if we can implement surround sounds or better background music to enhance the audial sensation.

VI. FUTURE WORK

In this work, we have collected many suggestions and comments about the system design and film contents from the user survey. In the future, there are several directions that we can work on to improve the quality of the design and conduct more in-depth studies:

(1) **Studying the effect of film genre:** Based on the analysis of user feedbacks in this study, we will try to change the styles of the film and conduct the experiments again to compare and understand how genre may affect the immersive experience of a user.

(2) **Studying the effect of film length:** We will conduct experiments to compare the effect of film

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length on the immersive experience. In this study, we have used a 5-min film to do the experiment. However, different film lengths (such as 30-sec advertisements, 10-min microfilms, 30-min short films, etc.) should also come with different interaction designs. For example, in a long film, a user may get tired easily if she needs to move her body to control the development of the story throughout the film. Instead, the interaction may be desired only in some critical sessions of the story.

(3) **Developing further applications:** In addition to applying the concept of interactive view changes to film watching, there could be many other applications that can adopt this kind of design. For example, the street view mode on Google Map can also use this method to replace mouse input in a guided tour. Other applications include on-line shopping and booking, serious games for navigation training, etc.

VII. CONCLUSION

In this work, we have used "interaction" to allow an audience to participate in a film and make the film watching experience more natural and intuitive. Consequently, richer immersive experience and better replay value have been observed in the conducted experiments.

Although the control of watching and story development have been somewhat transferred to the audience, the director still plays an important role in film making in such an interactive storytelling setting. This is because the role of director has been transformed to make the story convey more effective emotions through the use of interaction and story branching. We hope that, in the future, the design of more natural and intuitive interaction and seamless transitions between video segments can bring more and more possibility to the video-based interactive narratives.

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