Spaceline: A Concept for Interaction in Cinematic Virtual Reality

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Abstract
Watching omnidirectional movies via head-mounted displays places the viewer inside the scene. In this way, the viewer attends an immersive movie experience. However, due to the free choice of the viewing direction, it is possible to miss details which are important for the story. On the other hand, the additional space component gives the filmmakers new opportunities to construct non-linear interactive stories. To assist this, we introduce the concept of a *spaceline* which connects movie sequences via interactive regions. This work explains the terms of the spaceline concept and introduces methods that make it easier for the viewer to follow the story, at their own pace with their own focus. We present a design space that supports filmmakers in designing interactive CVR experiences.

Keywords: Cinematic Virtual Reality; 360° movie; omnidirectional movies, timeline; interactivity; story structure, nonlinear storytelling

1 Introduction

Already the Russian filmmaker Sergei Eisenstein had the desire for non-linear movies and books, in which the story can go on in all directions [1]. Cinematic Virtual Reality (CVR), where omnidirectional movies are watched via head-mounted displays, brings us closer to this dream of spherical dramaturgy. The additional space component facilitates interactivity in a natural way. Comparing traditional movies with CVR, many parallels can be found. However, the narrative methods of traditional film production cannot simply be transferred. The transition of some activities from the filmmaker to the viewer and new interaction possibilities requires and enables new approaches.

Traditionally, a movie is arranged on a *timeline*. Beginning and end of a shot are determined by in- and out-points. Brillhart adapted these terms: "In VR, the *in-point* is where a visitor's experience is most likely to begin and the *out-point* is where it's most likely to end." [2]. However, it cannot be assumed that the viewer really looks to the out-point at the time when the shot changes and therefore the in-point might not be seen. Moving away from tools of traditional film production and taking advantage of the possibilities offered by VR, opens up new options. Since CVR adds a space component in addition to time, it is worth to consider that cuts not only depend on elapsed time, but also on the viewing direction.

2 Spaceline Concept

Two fundamental terms of film montage are those of a shot and a scene. While a *shot* is a segment of a film between two cuts, a *scene* represents a unit of a movie at the same location and continuous in time, which in traditional film often consists of several shots. The number of cuts is reduced in CVR since the viewer himself selects different parts of the scenery for viewing. Often a scene has no further cuts. In a traditional film, the image of the camera and that of the viewer coincide. In CVR there are two perspectives: the around view of the camera and the smaller, self-selected *field of view (FoV)* of the viewer. The term shot is therefore not directly transferable, two terms are required for the film segment between two cuts. We distinguish between a space and a shot. A *space* is an omnidirectional movie segment that has been recorded without interruptions. The *shot* is the image sequence chosen by the viewer between the cuts, within this space. It is not omnidirectional, rather corresponds to the viewer's FoV in a space. A *spaceline* is a path through a structure of spaces. This structure is designed by the filmmaker. Based on it, the viewer determines the spaceline – a line through this construct consisting of several shots. In contrast to the timeline-based film, which is determined by the filmmaker alone, the spaceline is determined by the filmmaker and the viewer. Timeline and spaceline together set up the *storyline*.

Regions: The spaceline concept defines different types of regions: The *out-region* is the area whose activation ends a shot. From there, the switch to the next shot takes place, where the viewer first sees the *in-region*, from where the scenery then can be explored. The spaceline structure links out-regions with in-regions. In this way, shot changes become interactive, triggered by the viewer. For non-linear stories, more than one out-region can be defined in a space. In addition, we introduce *act-regions* which offer supplementary interaction options, such as enlarging details or retrieving additional visual information (embeddings) or sounds. One important characteristic of a region is the *size*: a large region is discovered faster than a small region. Regions can have different *priorities*: a region with high priority has to be discovered by the viewer before the story goes on, others are less important. A region can be activatable permanently, in a restricted time interval or just after another action was already activated.

Indicators: To make it easier for the viewer to recognize out- and act-regions, we introduce *indicators*. It is important that their visualizations do not disturb the viewing experience. *On-screen indicators* can be used for regions in the viewer's current FoV. To make the regions recognizable they can, e.g., be highlighted or framed. On the other hand, *off-screen indicators* point to regions out-of-display to make the discovery easier [3]. *Screen-referenced* items are connected to the display and move along with it in case the viewer is turning the head (e.g. arrows, buttons). *World-referenced* items are connected to the virtual world, in our case to the movie [14]. They stay fixed at their place in the movie world, even if the viewer turns the head (e.g. lights, signs). Indicators can inform about the direction of the target, the distance, the relevance and the type of the regions, e.g., by using different colors or sizes. Also, unmarked regions are conceivable, e.g. where the out-region is indiscernible for the viewer, but when looking at it for a certain time interval, the next shot starts.

Pointer/Activation: For selecting the out-region, *eye* or *head* tracking methods are most natural. However, also a *controller* or hand *gestures* are possible. A selection process consists of two parts: the *pointing* and the *activation* [6]. Both processes can go unnoticed by the viewer or be triggered actively. If head or eye tracking is used, the head/gaze direction is the pointer (cursor), which can be invisible for the viewer. Using *dwell-time* (looking for a certain time interval at a target) for activating the out-region, no additional devices are needed. If there is no feedback, the user does not notice why a space changes or any other action was activated. However, with this technique, it can happen that the viewer was not ready for the next space and would prefer to see more in the current space. Activation after a dwell-time interval could be randomly triggered but desired in certain constructions. It depends on the story if the selection and activation process should be unnoticeable or triggered actively by the viewer.

Table 1 shows the elements of the spaceline concept as a design space with four dimensions: region, indicator, pointer and activation. Each of these dimensions has several subdimensions. The values for the subdimensions which were discussed in the previous sections are listed and added by options which resulted from talks with VR and CVR experts. This design space is intended for support in designing applications for the spaceline concept, e.g. interactive CVR movies.

Table 1. Dimensions of the design space for the spaceline concept. The table shows for every dimension the subdimensions and options for the subdimensions

		option 1	*option 2*	*option 3*	*option 4*
region	*type*	in-region	out-region	act-region	
	size	small	middle	big	
	priority	high	medium	low	
	duration	permanent	restricted	sequence	
indicator	*type*	on-screen	off-screen		
	reference	world-referenced	screen-referenced		
	visibility	clear	unobtrusive	invisible	
	notification	direction	distance	relevance	type
pointer	*mount*	head	eye	controller	hand
	visibility	clear	unobtrusive	invisible	
	feedback	cursor change	target change	sound	none
activation	*mount*	head	eye	controller	hand
	trigger	nod/dwell	dwell/blink	click	gesture
	feedback	visual	auditive	haptic	none

2.1 Examples of Indicators and Pointers

There are several opportunities to draw the viewer's attention to regions on the screen, e.g. movements, arrows, lights, or colors. Examples for world-referenced, on-screen indicators are framed targets. The frame colors can be used for indicating different region types. The frame can be highlighted if the viewer's view is inside the region. It depends on the story how obvious such a frame should be. Since the viewer only sees a small part of the omnidirectional image in the HMD, regions can also be outside of the FoV. There are various possibilities for indicating off-screen objects on flat devices [7]–[10], in 3D environments [11] and augmented reality [12], [13] which can be partly adapted to CVR. Examples for screen-referenced off-screen indicators are signs on the edge of the display towards the off-screen region.

The easiest possibility for pointing in CVR is using the head direction, which is connected to the center of the display. Other examples are eye gaze, controller techniques or gestures. Pointers can also support the viewer's awareness of a region, e.g. by changing the color when it enters an act-region.

The visualization of the indicators and the pointer depends on the story content. The filmmaker has to decide how subtle or how obvious they should be. Different indicator types can be selected and customized in their appearance to the film project, similar to film transitions in timelines of traditional films.

3 Conclusion

In this conceptual paper, we introduced the novel concept of a spaceline for CVR, in analogy and addition to the traditional timeline. Film terms such as shot and sequence were transferred to CVR and explained in the new context. New terms as spaces, spaceline, in-, out- and act-regions were introduced and on-screen and off-screen indicators were presented.

We described the relation of the spaceline concept to traditional filmmaking. Our concept should encourage filmmakers to create CVR movies with dynamic non-linear story plots where scene changes depend on interactive regions defined by the filmmaker and selected by the viewer.

Reflecting on the overall concept in the CVR context, we highlight that spaceline and timeline are both needed to realize interactive storylines in CVR. Even when using the spaceline concept, filmmakers should be able to define the time limit of a shot.

We conclude that the spaceline is a valuable concept to support filmmakers in the process of designing interactive, non-linear CVR experiences. We presented first indicator designs and described their potential in guiding the viewer.

As a broader outlook, these methods are not only relevant for CVR but can also be adapted to virtual and augmented reality applications and motivate further research. It is important to know how viewers feel in different scenarios for developing a film language for Cinematic Virtual Reality. To support this process is the long-term goal of our research.

4 References

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