A new method of designing an interactive scenario of serious games based on panoramic videos

Daniel Xuan Hien Mai, Guillaume Loup, Jean-Yves Didier

A new method of designing an interactive scenario of serious games based on panoramic videos

Xuan Hien Mai[1], Guillaume Loup[1], Jean-Yves Didier[1]

[1]Université Paris-Saclay, Univ Evry, IBISC, 91020, Evry-Courcouronnes, France

Corresponding author: Xuan Hien Mai, maixuanhien.vn93@gmail.com
Keywords: interactive 360° video – serious game – authoring tool – finite state machine

Abstract

The increasingly low prices of virtual reality devices as well as omnidirectional cameras are stimulating the development of serious game applications using interactive 360 videos for the entertainment and training industries. While 360° video production is getting easier and faster, on the other hand, developing interactive content for scenarios of serious games remains time-consuming and manual, and requires a lot of programming knowledge. The lack of an interaction design standard based on a defined architecture can create misunderstandings between game designers and game developers, also making the development process costly and resource-intensive.

As a case study, we present a new design approach dedicated to serious games developed based on interactive panoramic videos which have the special control requirements in both temporal and spatial terms. This design will be introduced as a finite state machine (FSM), suitable for developing multithreaded scenarios.

1. Introduction

Omnidirectional cameras are becoming growingly popular, so producing 360° videos is easy and does not require specialist knowledge or complicated operations. Virtual reality headsets are also becoming cheaper and more accessible to the general public. Moreover, viewing 360° videos on a head mounted display (HMD) device provides a better sense of presence [3].

Traditional 360° videos are enriched by supporting additional interactive elements such as text information, sounds, 2D/3D objects, quizzes and so forth. These types of videos are transforming themselves into interactive 360° videos that not only improve user experiences, but also increase narrative and educational elements. These content-enriched interactions are typically structured to conform to the spatial and temporal dimensions of 360° video. That means they have a scripted fixed behavior. In addition, some other interactions that are based on user behavior, such as those that suggest vision navigation, will behave dynamically. Therefore, unlike editing tools of 2D videos that primarily deal with the temporal dimension, creating interactive 360° videos requires a whole set of tools to handle the combination of spatial and temporal dimensions.

In the production of serious games in general and educational applications in particular, the storyline is extremely important. A number of models have been proposed to help define the main components of this type of application; however, there are additional factors that need to be specifically considered when developing serious games based on the main content of interactive 360° videos.

In this article, we rely on *scenario-based design* [2] approaches to propose a design approach specific to serious games that uses interactive 360° videos and identifies the core components of a system architecture. In the future, we will explore the interactive modules and tools necessary for a useful authoring tool in this context, where an author can create his application while being totally immersed in virtual reality.

2. Related work

2.1. Interactive 360° videos

Using a virtual reality headset to watch 360° videos allows users to be completely immersed in a virtual scene and see the videos in the direction of their choice by turning their head [1]. Regarding the design tools for 360° videos in virtual reality, the usability of the rapid object creation solution was evaluated [9] through tasks such as adding and removing 3D objects in space and time. The panoramic view provides high-fidelity environments [11] and contributes to a sense of presence [6]. Although much of the work consists of simple interactions, an experiment was performed to assess the continuity of the integration of video animations, 3D interactive objects as well as 3D audio [4]. For the design of immersive panoramic videos, the designer's assistance is mainly limited to primitive virtual behavior techniques such as selection [7]. When it comes to game mechanics, interaction techniques are also limited to simple tasks such as managing a score [5].

2.2. Serious game designs

Designing an effective and enjoyable serious game requires not only knowledge of learning domain or pedagogy, but also an understanding of scenario design and game design components. In this context, several models of design have been proposed. Stephen Tang and Martin Hanneghan [10] have proposed a *Game Content Model* which provides definitions of design structure, helping to shed light on important elements of serious game design. Yen-Ru Shi and Ju-Ling Shih [8] investigated 11 important elements of game design, namely purpose, mechanics, fantasy, value, interactivity, freedom, storytelling, sensory, challenge, sociability and mystery. These studies are of great help in the analysis and development of architectural archetypes of serious educational games.

Concerning design methodology, in order to increase the educational value of serious games, it is necessary to add mechanisms that allow the player to interact with the environment. These additional interactions enhance the user's sense of presence as it creates a sense of control and real participation in the scenario [16]. In addition, the content of serious games should be divided into several difficulty levels. The access will be granted according to the results of the previous level [12]. In other words, it is an adaptation that allows the playing environment to change to suit the style or skill level of the player. This further confirms the need to take adaptive mechanics into serious gaming. For this purpose, the scenario of the game can be thought of as a state transition system (finite state machine) and there will be evaluation and adaptation mechanisms based on checking and modifying specific states of the system [13].

2.3. Scenario of serious game based on 360° video

Videos in general and panoramic videos in particular are narrative in themselves. Their content was determined before the production process [14]. In other words, the video itself is part of the serious game storyline. 360° videos can be seen from multiple angles (active) instead of just being observed from the director's point of view (passive) [6]. Therefore, additional interactions are needed to get the player to follow the correct progression of the storyline and watch the video in the right direction at critical times.

Not only the spatial factor, but also the temporal factor must be evaluated when considering the effect of additional interactions on the timeline of the video, and more broadly their effects on the entire timeline of the scenario. The studies by Toro, M. [15] initially confirmed the viability of fixed-time and flexible-time models in conditional branching scenarios. However, they must have certain conditions to be maintained in the scenario.

An example of a scenario is the virtual visit of a museum composed of interactive panoramic videos of each room presented by a guide. The aim is to make a visit more accessible and more adapted to the preferences of each visitor. Thus, it is possible to navigate from room to room quickly and effortlessly. In addition, interactive buttons positioned on the video allow the visitor to get additional information on each work. 3D areas are also positioned on the video to highlight the work evoked by the guide. Finally, a questionnaire can also appear at the end of the video to measure the visitor's understanding.

We examined a few authoring tools that support 360° video and multi thread scenarios to learn about their programming knowledge requirements and operational complexity. Table 1 below lists some typical tools for VR applications, which have been analyzed qualitatively and statistically, including: Amazon Sumerian[1], InstaVR[2], Dataverse[3] and FlowMatic [18]

Table 1 : authoring tools for VR experiences

	360° video support	Authoring tool platform	Multi-thread scenario support	Progamming knowledge	Complexity
Amazon Sumerian	yes	PC	--	high	high
InstaVR	yes	PC	no	no need	medium
Dataverse	yes	PC	no	no need	--
FlowMatic	no	VR	yes	medium	high

There are very few authoring tools built directly on the virtual reality platform but mainly still authoring tools on PC. The simulated viewpoint (on the 2D screen) of these tools therefore deviates from the actual viewpoint in VR, which can lead to deviations in spatial positioning when designing interactions.

In order to be able to design standard tools suitable for a no-code immersive authoring tool, it is first necessary to have a standard method of design that describes in detail the components of an interactive scenario of a serious game based on 360° videos.

3. Method of design towards a no-code immersive authoring tool

Towards the goal of building an intuitive and easy-to-use immersive authoring tool that allows non-programming savvy authors to easily develop their serious game apps based on 360° videos, firstly, we will introduce in this paper a new method of design for interactive scenario that we find appropriate, considering the characteristics of serious games as well as the special control requirements in both temporal and spatial terms for interactive 360° videos.

In the architectural design for serious games based on 360° videos that we come up with, the most basic unit is the scene (Figure 1). Each scene includes a segment of the video with additional interactions (text, sound, 2D/3D objects and so on.). The video segment is spanning between two time values and therefore additional interaction configuration time parameters are bounded by these two values.

Linear video time is irreversible. Therefore, a special object will allow the video to be paused at a specific time. Interactions installed in this object when the video is paused will behave differently from linear interactions. This design guarantees the possibility of controlling the temporal in the scene, allowing the addition of many interesting gameplay such as answering quizzes without any time limit.

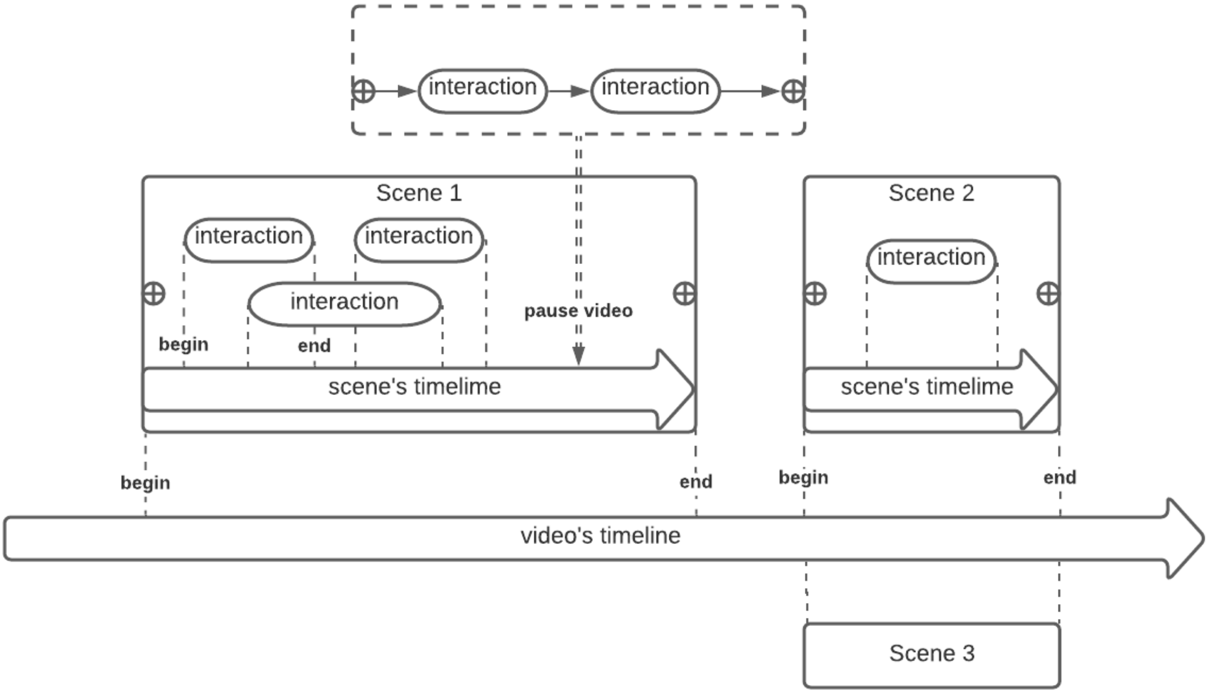

Figure 1 : The elements in the scene based on 360° video

This design is distinguishable by its ability to visually depict the occurrence of interactions on the video's timeline, suggesting to the author about the layout arrangement of objects and interactions in the scene, helping to develop a better scenario structure.

The goal is to develop an immersive authoring tool, so the spatial parameters will be adjusted by the author directly in the virtual environment. A preview mechanism will be provided so that the author can "try it out" from the perspective of the end user.

This is essentially a timeline tree model [17] in the interactive scenario. Scenes 2 & 3 are transitions after scene 1 but on the same video. In the design of the operating system (application system), the two *Data Manager* and *Scene Manager* modules will work independently but cooperatively to ensure the seamlessness of the video content as well as the multi-threading of the scenario. This architecture also helps to save video storage resources as multiple scenes can be edited on the same video. The author does not need to go through the pre-production process to cut and edit the video for each individual scene.

Using scenes as the basic material for scenario building, we have 3 basic components of an interaction scenario: the scenario segment, the transition and the condition.

Scenes will be placed in scenario segments and can be re-used in the same segment or between segments, depending on the scenario design. The *transitions* between the segments of a scenario will be made after evaluation of the results on the basis of the binding *conditions*. Figure 2 will explain the transition state of the finite state machine (FSM) in the system.

All player actions and interactions in the game will be logged in the event log. The analysis of event log data will help determine the state of the system. However, it is not necessary to define the entire state at each evaluation. This design allows the author to build his own evaluation rules at each transition point on the scenario, with a finite number of events analyzed.

The output of each evaluation will be a binary result leading to two different branches of the scenario. The whole scenario will have the structure of a binary network. Therefore, it is necessary to develop algorithms to detect infinite loops in the scenario.

A segment can also reside within another segment, which increases the possibility of designing multi-threaded scenarios. But at the same time this multi-tier architecture also poses an ergonomic design challenge on the development of authoring tools.

The design approach we propose has integrated a FSM, suitable for interactive scenarios where user interactions in the scene will affect scenario progress.

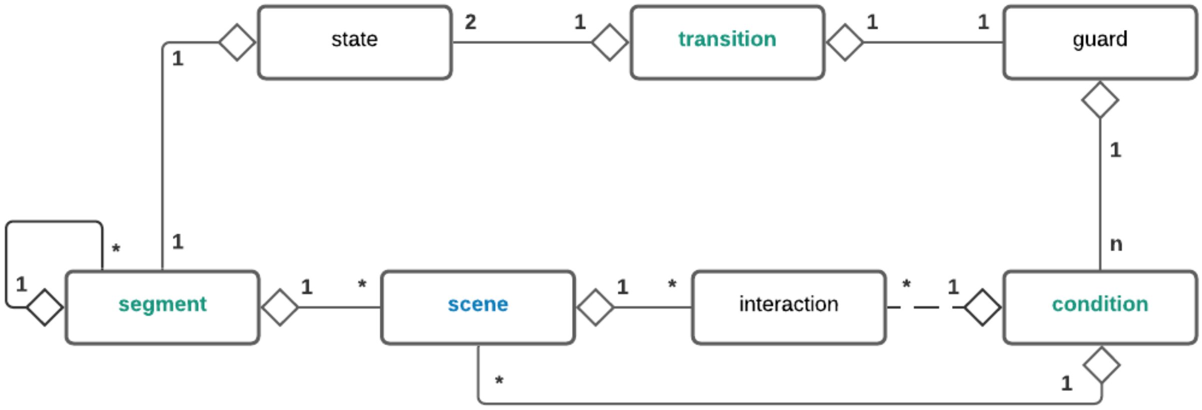

Figure 2 : The transition state of FSM in the system

A loose link between *condition* and *interaction* means that the evaluation conditions of the scene will be analyzed based on the results of user interactions in the scene. It could be for example the results of answering the questions, the time it took to answer the questions, or the total time spent in the scene and the like.

Thus, we have just introduced an overview of the design approach for the interactive scenario of serious games based on panoramic videos. This approach is suitable to help the author develop his game by describing scenarios using storyboards. It should be noted that for this part of the architecture, the multithreading scenario is purely mechanical, which means that the system has a finite state and the state changes are only based on the results of real-time user interaction. In the future, a larger architecture based on adaptive learning models [21][22] will be developed, using the resources of this design approach in combination with artificial intelligence techniques, for example machine learning and deep learning to analyze data profile and user behavior to offer appropriate suggestions.

4. Conclusion

This article proposes a new method of design that enables authors to build serious gaming applications based on interactive 360 videos. The proposed model follows scenario-based design, which is the result of a serious analysis of different game architectures, considering the particular properties of 360 video and additional interactions.

Encapsulation of video segment within the scene ensures the integrity of the story in the video. This design gives the author more control over the video's timeline. Additionally, using video segments instead of the entire video, along with FSM integration, makes it easier for authors to build multi-threaded scenarios with additional interactions in the scene.

Based on this architecture, we are developing an immersive authoring tool that allows users to create applications directly in a virtual reality environment without the need for programming knowledge. Our challenge was to study ergonomics in order to develop a suitable storyboard interface in virtual reality.

In the next stage, based on the scenario classification [19][20], after finalizing the authoring tool, we will design and conduct certain appropriate experiments to test the adaptability of this design to different scenario types.

In the future, we will study the possibility of integrating artificial intelligence as well as machine learning, deep learning to complete the adaptive learning model for this architecture.

5. Acknowledgments

This project was supported by the ANRT (PhD fellowship) and the WideWebVR company (CIFRE #2020/0813).

6. Notes

[1] https://aws.amazon.com/sumerian

[2] https://www.instavr.co

[3] https://dataverse.xyz

7. References

[1] Oliver, A., del Molino, J., & Bibiloni Coll, A. (2020, June). Palma360: A 360-degree Web-based Multi-device Hypervideo. In *ACM International Conference on Interactive Media Experiences* (pp. 165-169). doi:10.1145/3391614.3399394

[2] Carrol, J. M. (1999, January). Five reasons for scenario-based design. In *Proceedings of the 32nd Annual Hawaii International Conference on Systems Sciences. 1999. HICSS-32. Abstracts and CD-ROM of Full Papers* (pp. 11-pp). IEEE.

[3] Chambel, T., Chhaganlal, M. N., & Neng, L. A. (2011, November). Towards immersive interactive video through 360 hypervideo. In *Proceedings of the 8th international conference on advances in computer entertainment technology* (pp. 1-2). doi:10.1145/2071423.2071518

[4] Choi, K., Yoon, Y. J., Song, O. Y., & Choi, S. M. (2018). Interactive and immersive learning using 360 virtual reality contents on mobile platforms. *Mobile Information Systems*, *2018*. doi:10.1155/2018/2306031

[5] Argyriou, L., Economou, D., Bouki, V., & Doumanis, I. (2016, December). Engaging immersive video consumers: Challenges regarding 360-degree gamified video applications. In *2016 15th International Conference on Ubiquitous Computing and Communications and 2016 International Symposium on Cyberspace and Security (IUCC-CSS)* (pp. 145-152). IEEE. doi:10.1109/IUCC-CSS.2016.028

[6] Violante, M. G., Vezzetti, E., & Piazzolla, P. (2019). Interactive virtual technologies in engineering education: Why not 360° videos? *International Journal on Interactive Design and Manufacturing (IJIDeM)*, *13*(2), 729-742. doi:10.1007/s12008-019-00553-y

[7] Horst, R., Diez, S., & Dörner, R. (2019, October). Highlighting Techniques for 360 Video Virtual Reality and Their Immersive Authoring. In *International Symposium on Visual Computing* (pp. 515-526). Springer, Cham. doi:10.1007/978-3-030-33720-9_40

[8] Shi, Y. R., & Shih, J. L. (2015). Game factors and game-based learning design model. *International Journal of Computer Games Technology*, *2015*. doi:10.1155/2015/549684

[9] Adão, T., Pádua, L., Fonseca, M., Agrellos, L., Sousa, J. J., Magalhães, L., & Peres, E. (2018). A rapid prototyping tool to produce 360° video-based immersive experiences enhanced with virtual/multimedia elements. *Procedia computer science*, *138*, 441-453. doi:10.1016/j.procs.2018.10.062

[10] Tang, S., & Hanneghan, M. (2011, December). Game content model: an ontology for documenting serious game design. In *2011 Developments in E-systems Engineering* (pp. 431-436). IEEE. doi:10.1109/DeSE.2011.68

[11] Pan, Y., & Mitchell, K. (2020, March). PoseMMR: a collaborative mixed reality authoring tool for character animation. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)* (pp. 758-759). IEEE. doi:10.1109/VRW50115.2020.00230

[12] Barbosa, A. F., Pereira, P. N., Dias, J. A., & Silva, F. G. (2014). A new methodology of design and development of serious games. *International Journal of Computer Games Technology*, *2014*. doi:10.1155/2014/817167

[13] Moreno-Ger, P., Burgos, D., Martínez-Ortiz, I., Sierra, J. L., & Fernández-Manjón, B. (2008). Educational game design for online education. *Computers in Human Behavior*, *24*(6), 2530-2540. doi:10.1016/j.chb.2008.03.012

[14] Feurstein, M. S. (2018). Towards an integration of 360-degree video in higher education. Workflow, challenges and scenarios.

[15] Toro, M., Desainte-Catherine, M., & Baltazar, P. (2015). A model for interactive scores with temporal constraints and conditional branching. *arXiv preprint arXiv:1510.02836*.

[16] Argyriou, L., Economou, D., Bouki, V., & Doumanis, I. (2016, December). Engaging immersive video consumers: Challenges regarding 360-degree gamified video applications. In *2016 15th International Conference on Ubiquitous Computing and Communications and 2016 International Symposium on Cyberspace and Security (IUCC-CSS)* (pp. 145-152). IEEE. doi:10.1109/IUCC-CSS.2016.028
[17] Hirzalla, N., Falchuk, B., & Karmouch, A. (1995). A temporal model for interactive multimedia scenarios. *IEEE MultiMedia*, *2*(3), 24-31. doi:10.1109/93.410508
[18] Zhang, L., & Oney, S. (2020, October). FlowMatic: An Immersive Authoring Tool for Creating Interactive Scenes in Virtual Reality. In *Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology* (pp. 342-353). doi:10.1145/3379337.3415824
[19] Rosson, M. B., & Carroll, J. M. (2002). *Usability engineering: scenario-based development of human-computer interaction*. Morgan Kaufmann.
[20] Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: towards a user's guide. *Futures*, *38*(7), 723-739. doi:10.1016/j.futures.2005.12.002
[21] Arsovic, B., & Stefanovic, N. (2020). E-learning based on the adaptive learning model: case study in Serbia. *Sādhanā*, *45*(1), 1-13. doi:10.1007/s12046-020-01499-8
[22] Yang, T. C., Hwang, G. J., & Yang, S. J. H. (2013). Development of an adaptive learning system with multiple perspectives based on students' learning styles and cognitive styles. *Journal of Educational Technology & Society*, *16*(4), 185-200.