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How Does the Screen Expansion in the Images through Generative AI Affect the User Experience of Watching the Video on XR Environments?

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Abstract

The advent of generative AI, which has recently emerged, signifies the ability to create images by expanding upon existing images and filling in empty areas. Consequently, this research examined the impact of providing expanded images on the existing movie screen on usability when watching a movie while wearing XR equipment. This is because when a video with a 16:9 or 21:9 aspect ratio is viewed while wearing an XR device, the video can be expanded to occupy the entire screen in extended reality. The experimental design entailed the real-time capture of the movie screen using Adobe's generative AI, followed by the expansion of the captured image and its manipulation in both the vertical and horizontal directions. The video comprises a 15-second movie, featuring a VR scenario. A usability evaluation (SUS) was conducted, utilizing this function to expand the screen area. The experimental results substantiated the positive impact of generating images in real-time through generative AI on an XR device that expands the screen area through generative AI.

Keywords: Generative AI, user experience, screen, XR, service design

1. Introduction

Recent advancements in over-the-top (OTT) media services have introduced immersive and interactive movie-viewing experiences utilizing extended reality (XR) technologies, particularly virtual reality (VR) and mixed reality (MR). These technologies transcend spatial and temporal constraints, offering a novel approach to media consumption distinct from conventional cinematic experiences.

Apple’s release of Vision Pro represents a significant development in this domain. As a spatial computing device and MR headset, it is designed to recognize user gestures and movements, enabling a more interactive viewing experience. MR, which integrates VR and augmented reality (AR), overlays virtual elements onto the physical environment, creating a seamless interaction between digital and real-world content. Unlike VR, which primarily functions as an extended display, MR facilitates a more integrated and interactive experience.

Prior research has shown that VR-based media consumption enhances immersion by increasing engagement and empathy (Zhang & No, 2023). Furthermore, VR-enabled movie viewing differs from traditional screen-based experiences due to its distinct visual stimuli, which influence user perception in ways not observed in flat-screen displays (Lee & Lee, 2024). Recent research on the XR environment has focused on user experience. The study cited above demonstrated the efficacy of images that are contextually related to the screen being viewed. Additionally, other research suggests the integration of both visual and auditory senses. However, extant research has not focused on the interface design when users enjoy video content in an XR environment (Davari & Bowman, 2024; Stanney et al., 2021).

Building on these findings, this study hypothesizes that MR-driven screen expansion will significantly impact user engagement and immersion. The present study focuses on the XR environment of Apple Vision, as postulated in the aforementioned hypothesis. This is Vision Pro’s current movie-viewing method remains constrained by certain limitations. Although the display dynamically adjusts to the user’s gaze, video content is still confined to fixed aspect ratios, such as 16:9 or 21:9. As a result, the experience is largely limited to that of a virtual theater, rather than a fully immersive, spatially interactive environment.

Accordingly, this study aims to assess the impact of MR-based screen expansion features on usability and user experience, determining whether they provide a meaningful improvement over conventional screen-based media consumption.

2. Literature Review

2.1 The device for MR

The integration of VR, and AR within MR signifies a substantial advancement in technology. The incorporation of advanced artificial intelligence (AI) into MR systems, which seamlessly blend virtual and real elements, has been demonstrated to enhance depth perception and expand the field of view, thereby providing a more immersive experience compared to conventional VR-based environments (Son & Kim, 2023). In the dematerialized spatial context of MR, increased realism has been demonstrated to enhance user enjoyment, memory retention, and emotional arousal (Baek, 2023). Furthermore, research indicates that a heightened sense of presence and engagement in virtual environments within MR leads to more positive outcomes than those observed in VR-only experiences (Kim et al., 2024).

As MR continues to evolve, its integration with VR-based systems is expected to facilitate a seamless convergence of real-time digital interactions with physical reality, thereby extending the scope of VR beyond passive viewing toward more interactive and participatory experiences. Consequently, MR devices are gaining attention as a transformative medium for video consumption, surpassing spatial and temporal constraints associated with traditional screen-based methods. A notable example of this technological advancement is Apple‘s Vision Pro, which introduces a novel user experience by redefining the way digital screens and user interfaces (UI) are perceived and interacted with in environments. The user interface and screen experience of Apple Vision is illustrated in <Figure 1>.

Figure 1. The case of the Apple Vision

2.2 Expand the Screen Area of the Video Content

Recent advancements in display technology have resulted in a gradual increase in the dimensions and aspect ratios of smartphones, monitors, and television screens, thereby altering how users experience visual content. These changes have introduced new viewing paradigms, including horizontally expanded displays and 1:1 aspect ratio video format. Among these innovations, a particularly noteworthy development is the screen expansion method, which facilitates the extension of video content beyond the confines of the device's physical display area.

Research has demonstrated that expanding the visual area on device screens can enhance the user experience by increasing the amount of relevant content displayed, thereby contributing to a more immersive viewing experience (Kim, 2015). A notable illustration of this screen expansion technique is Philips's smart lighting technology, which enhances video consumption through dynamic ambient lighting. The Philips Hue LED smart lighting system, a prime example of this technology, synchronizes in real-time with the colors displayed on the screen, projecting corresponding hues onto the surrounding environment. This approach, which extends the perceived screen beyond the physical display, is particularly effective in enhancing entertainment experiences such as gaming and movie viewing by increasing visual immersion. <Figure 2> provides a visual representation of this implementation.

Figure 2. Example of screen expansion using Philips Hue strap lighting

The positive impact of extending the visual experience beyond the display on human senses and consciousness has been demonstrated (Lee, 2017). This positive experience can be attributed to the expansion of content that is congruent with the context of the video, resulting in the creation of a novel experience (Kim & Kim, 2012). The space-centered expansion experience, which extends beyond the confines of the screen and leads to the expansion of space, has been shown to enhance the sense of presence and improve the overall experience of watching movies (Che, 2018).

2.3 The Screen Expansion based on Generative AI

In the ongoing development of AI technology, generative AI has demonstrated the capacity to expand and fill the screen area to the level of real images. Adobe's generative AI service, dubbed "Firefly," exemplifies this capacity, effectively utilizing the canvas to expand and fill images. When expanding the image area (canvas), Firefly has a function to create an empty area with an image related to the visual elements expressed in the set image. This function utilizes generative AI to activate the desired portion of the image, prompt the user with an image, or align the generated content with the existing image. As illustrated in <Figure 3>, this capability allows for the seamless integration of generated content within existing visual frameworks, facilitating the creation of dynamic and personalized visual experiences.

Figure 3. Example of image creation and expansion with Adobe 'Firefly'

In addition, the aforementioned functions are present in the recently introduced image generation AI. Runway and Sora, which are services of video generation AI, regenerate images into videos and create new images for each frame that fit the context of the video to compose the video. This capability underscores the potential of generative AI to comprehend and replicate visual information and context inherent within an image, thereby filling in gaps or incorporating it as a component of the image.

3. Literature Review

3.1 Pre-Survey

The objective of this research is to ascertain the impact of the visual experience of video content displayed on the device's screen. To this end, the study employs generative AI technology to generate images or videos that align with the context of the visual content on a canvas area external to the screen in real-time. To this end, the study has developed a pre-survey, comprising both a constructed survey and in-person interviews, to ascertain the actual reactions to the augmentation of the movie screen area. The pre-survey was conducted from March 10 to 13, 2024, targeting 55 users in their 20s and 30s. It employed a Google form to collect multiple-choice responses and conducted in-depth interviews based on the responses to the questions. After the collection of these responses, the subjective answers were methodically organized and analyzed, with a particular focus on identifying any overlapping contents. The results of the preliminary survey and interview are displayed in <Table 1>

Table 1. Result of pre-survey(n=55)

Questions	Answers
Q1-1. Have you experienced a lack of immersion when watching a movie in a movie theater?	*Yes (71.8%)* *No (28.9%)*
Q1-2. If you didn't feel immersed in it, why are you think about that? (Only 'Yes' respondents to Q1)	*- The noise of the audience, such as laughter and movement.* *- The emergency exit and the lighting on the floor came into view.* *- The boundaries were annoying with a small screen size.*
Q2-1. If the movie screen area is not limited and can be expanded, do you think it will have a positive effect on improving immersion?	*Yes (72.7%)* *No (27.3%)*
Q2-2. Why are you think about that? (Only 'Yes' respondents to Q2)	*- To feel a sense of reality.* *- To feel the liveliness of the movie.* *- If the vision is full on the space, it will be immersed well.* *- It would be good watching if the screen is expended, but there are also concerns about the parts that will be missed about main contents.*
Q3. What do you think I should be aware of when watching a movie through an MR (mixed murder) device?	*- Block vision, making it easier to focus with my surroundings.* *Distinguish the difference in focus between important and non-critical scenes on the screen.*

In the preliminary survey, more than half of the respondents (71.8%) responded negatively to the sense of immersion in movie theaters. The majority of respondents anticipated that an increase in screen area would enhance immersion by providing a more vivid sense of liveliness and presence. However, concerns regarding the potential loss of visual elements if the screen were to be enlarged were also expressed. Consequently, there is a call for a pronounced emphasis on the primary content. It is predicted that the experience of blocking the user's view and providing mixed reality can be positive. Furthermore, it was determined that the content displayed on the extended screen, other than the primary video content, should consist of images that are of minimal importance. This is because a wide screen can rather reduce the concentration of users.

3.2 Research Objective

The objective of this research is to enhance immersion in MR by exploring novel approaches to video consumption. MR and VR devices have been shown to influence the user experience through a unique form of visual stimulation, distinct from conventional flat-screen viewing (Lee & Lee, 2024).

To investigate movie viewing in MR environments, this study establishes an experimental scenario based on Apple's Vision Pro. The introduction of Apple's "Submerged," a film designed specifically for Vision Pro, exemplifies an alternative approach to film consumption. Given Vision Pro's potential to redefine video experiences, it was deemed an appropriate device for user scenario development and UI design in this study.

The proposed method for enhancing movie-viewing experiences involves generative AI-driven screen expansion. Specifically, generative AI is employed to generate visual content that extends beyond the confines of the primary display area, with this additional imagery being rendered in real time. This approach builds on existing technologies, such as Adobe Firefly's generative AI, which generates content in blank areas outside the primary screen (see Section 2.3, Screen Expansion Based on Generative AI), as well as AI-powered video generation models like OpenAI's Sora. This technique enables users to experience a 360-degree visual environment, transforming the surrounding space into an extended virtual reality rather than a traditional screen-based viewing experience.

To address potential disruptions in narrative perception, this study incorporates a blur effect in expanded areas beyond the primary screen as the user's gaze shifts. This ensures that while the screen expands, the original focus of the film remains intact. Additionally, if a user's attention deviates excessively from the intended focal point, the system reduces the audio output, subtly prompting the viewer to reorient toward the central movie screen.

Based on the above, this research predicts that there will be a positive effect on the user experience when the 360 degree of the user’s sight wearing the XR device is composed of an image related to image content. And then, the possibility of an XR image content viewing method using generative AI is confirmed.

3.3 Concept UI Design

In the experiment, when video content is played, the screen within the user's field of view is configured by filling the entire screen with video and filling the user's upper, lower, left, and right gaze with related video images. In this process, the 21:9 ratio video, in which the video content is implemented, is placed in the exact center of the user's field of view. The video, which was generated in real time, was organized based on the user's top, bottom, left, and right sides. Finally, regions extending beyond the aforementioned dimensions are subjected to a blur effect, thereby restoring the screen to its original movie perspective. Furthermore, given the absence of the developing AI service, Adobe AI “Firefly” was utilized to generate the associated screen region following the capture of the screen’s content. This was achieved by maintaining the camera’s perspective fixed at the level of the video’s visual elements, thereby ensuring a static viewpoint. The generated imagery, which constituted the periphery of the video’s content, was subjected to the application of a blur effect, a manipulation intended to reduce the user’s level of focus. To this end, a request was formulated to prompt the insertion of an image-related image and the blur effect into the prompt. The UI structure based on the aforementioned standards is illustrated in <Figure 4>.

Figure 4. The construct of UI design with video contents

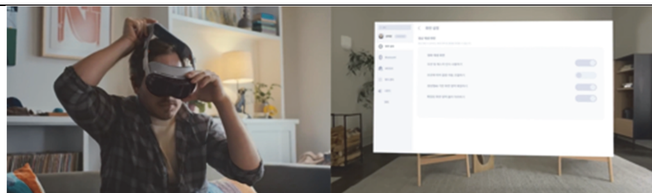
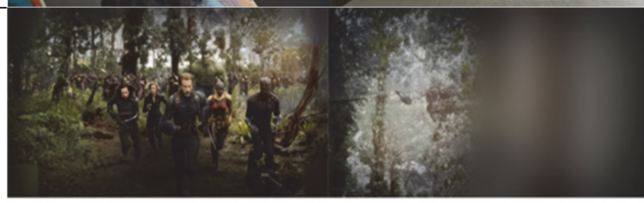
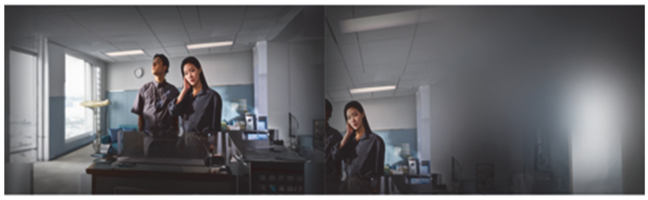
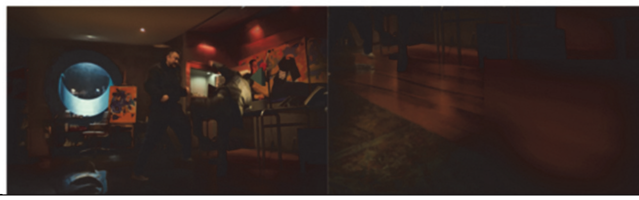
The front direction of the XR device is the (1) image area of <Figure 4>. And the upper, lower, left, and right screens connected to (1) is the (2) area. Furthermore, the screen connected diagonally to (1) is the (3) area. Accordingly, the screen connected at 360 degrees is set to be composed of the screens (2)-(2) and the screens (2)-(3). As described above, for the experiment, the concept considered a situation that could lead the field of view to 360 degrees for the environment for viewing image content in the XR device. To this end, the situation of the environment for viewing the content image of the user wearing the XR device is summarized as shown in <Figure 5>.

Figure 5. Conceptual environment of a user's sight wearing the XR device

The video displayed in the UI for the experiment consisted of one video provided by YouTube and three films. Each video is displayed for approximately 15 to 20 seconds. Before the implementation of the aforementioned UI design, a video was employed to facilitate subject comprehension regarding the process of wearing Apple Vision. The experiment was structured as a video-based study, with the overall process spanning 1 minute and 35 seconds.

The rationale behind employing a scenario video with a prototype stems from the observation that the outcomes of utilizing the product directly and viewing a prototype video are found to be highly consistent (Jang & Yun, 2021; Woods et al., 2006). The video process is delineated in <Table 2>.

Table 2. The experiment for concept

Scenario	Concept
#1. Wearing Vision Pro and Screen (1~13s)	
#2. Play the 3 video contents and move from main area 1 to area 2 and 3 constricted generative image by AI. (14~74s)	  

4. Analysis

4.1 Pre-Survey

This research utilizes the scenario video experiment depicted in Table 2 to conduct usability verification. The SUS test is a method of verifying the possibility of the service relatively quickly through user evaluation before the service is provided. The method of viewing video content presented in this study involves an AI utilization service that generates images related to the screen of video content in real-time through generative AI. This is achieved by leveraging Firefly, an Adobe Generative AI service, which composes images by extracting contextual information from the top, bottom, left, and right sides of the video screen.

The effective usability scale, SUS (System Usability Scale), was utilized for the verification process. The SUS comprises 10 questions that evaluate the level of agreement and are standardized questions that aim to evaluate the whole by mixing positive and negative. Additionally, unstructured, subjective questions were incorporated to collect factors or environments that influenced the quantitative research results. This was due to the expectation that various insights, including content related to immersion, which was an existing problem, would be derived as a response factor. The survey's contents are delineated in <Figure 3>.

Table 3. The contents for SUS and question

Number	Questions
1	I think that I would like to use this system frequently.
2	I found the system unnecessarily complex.
3	I thought the system was easy to use.
4	I think that I would need the support of a technical person to be able to use this system.
5	I found the various functions in this system were well integrated.
6	I thought there was too much inconsistency in this system.
7	I would imagine that most people would learn to use this system very quickly.
8	I found the system very cumbersome to use.
9	I felt very confident using the system.
10	I needed to learn a lot of things before I could get going with this system.
Answer Question	Please feel free to describe the factors or environment that influenced the above evaluation.

4.2 Result of SUS Test

The experiment's participants are young adults aged 20 to 30 who exhibit a high level of engagement and interest in generative AI. A total of 117 individuals partook in the survey, which was conducted from November 10 to December 10, 2024. The Google Form was employed as the survey collection method, and it was administered online.

The SUS test is considered to be usable if the average result of each experiment participant is 75 points or higher. The evaluation result of the SUS test in this study was 78.13. Consequently, it can be concluded that the concept service in this study exhibits a satisfactory level of usability.

Furthermore, this research investigates whether the SUS results of each experiment participant constitute a normal distribution. This is to ensure that the resulting values have high reliability and maintain a normal distribution. The normality test involves two distinct assessments: the Shapiro-Wilk test, which is particularly effective when the number of parameters is limited, and the Anderson-Darling test, which verifies the attainment of a specific normal distribution.

The normality test results indicate that the p-value (Sig) is lower than the significant variable 0.05, thereby confirming the reliability of the experiment's results. Consequently, the outcomes of this experiment can be regarded as highly reliable. The results of this study are presented in <Table 4>.

Table 4. The result of SUS and Normality test(n=117)

M	Normality test			
	Shapiro-Wiki		Anderson-Darling	
78.13	Statistic	Sig	Statistic	Sig
	083 [a]	.000	1.878 [b]	.001

[a] $p \leq 0.05$, [b] $p \leq 0.01$, [c] $p \leq 0.001$

The findings of the present study confirmed the possibility of XR devices displaying images related to video content in all 360 degrees, as presented in 3.3 (Research Objective) through the SUS test. Consequently, the study's findings, derived from the SUS test's result value of 78.13, predict a favorable user experience for services that generate images related to video content in real time within the XR environment.

4.3 Discussion

After the administration of the SUS survey, subjects' opinions were collected through subjective questions. The responses were then grouped and organized, resulting in the identification of three insights.

Primarily, the factors that garnered the highest percentage of responses were immersion and environmental adaptation. The respondents articulated a variety of perspectives on the potential benefits of enhanced immersion in cinematic experiences, emphasizing its capacity to enrich the viewer's engagement with the narrative. They further noted its convenience, suggesting that it facilitates a deeper and more comprehensive experience that transcends the limitations of the traditional movie-going environment. Additionally, the importance of immersion was underscored by the observation that its more natural presentation would enhance the experience.

“I think it will be very useful because you can watch it anytime, anywhere with a movie-like feel. I think it is an interesting service in that it can provide a sense of immersion.” (P5, 35)

“It was very uncomfortable and annoying to wear glasses when watching 4D or 3D, but I think it will be more immersive and fun to watch in this way, so it’s very interesting.” (P11, 97)

"Watching a movie with this technology felt novel because it made me feel like I was actually in a movie. I think it's nice that I can see both sides and behind me, not just the front." (P38, 84)

Second, various experiences and personalization factors. There are differences in the way people enjoy movies, and we were able to find opinions that the need can be met by being able to enjoy movies in a variety of ways. There were also opinions that it would be good to provide services tailored to each situation.

“Because the movement of the eyes is natural, I think I will be able to experience much richer things than I can now when watching a movie.” (P24, 45)

“I think it would be better to use it when watching a movie again and again. I think it can satisfy the needs of additional questions or regrets about the movie.” (P51, 92)

“I think there are differences in how people enjoy movies, so I think it would be fun to provide a service tailored to each situation. It would also be fun to limit the viewing angle when watching while lying down or use the perspective of sound.” (P63, 101)

Third, there are technical limitations and practicality factors. As AI is still going through trial and error for development, concerns have been raised about technical limitations, such as the possibility of incorrectly reflecting the thoughts or intentions of the creator. There was also a response that clear guidance on how to operate was needed.

“I am concerned that AI may have a negative impact on unique creations by incorrectly reflecting the creator’s thoughts or intentions.” (P15, 112)

“I hope it will be clearer what needs to be done after wearing the device for the function to work. Also, if you look elsewhere due to interference from your surroundings, you may miss important scenes in the movie.” (P53, 78)

“There are concerns that immersion may be hindered by excessive screen transitions in dramatic or important scenes, so it would be better if there were some preventative measures, such as limiting the screen size or gradually fixing the viewpoint.” (P65, 90)

5. Conclusion

This research confirmed the potential for a new movie market by complementing the problems of XR's interactive movie viewing method with MR-generated content. Through meticulous research, it was ascertained that utilizing XR devices for cinematic viewing has the potential to enhance user immersion and participation, thereby inducing profound empathy. In light of these findings, the present study focused on enhancing the user experience through the implementation of generative AI-based screen expansion functions. The implemented experiment yielded an expanded video experience that was designed to take into account the user's perspective, and the results of the usability verification process confirmed positive responses from the participants. The experiment garnered significant interest, with participants expressing enthusiasm for generative AI-based extended reality movie viewing methods. Notably, positive evaluations were particularly high for immersion and environmental adaptation factors. However, concerns regarding technical limitations and practicality factors were also raised, along with the necessity of considering diverse participant perspectives based on their experience and individualization requirements.

The significance of this research is that it confirmed the positive impact of generating images in real-time through generative AI in XR devices. This is noteworthy because while prior research has examined cases involving the expansion of the video area, research employing video and image generation AI remains underdeveloped. Consequently, this study proposes a novel innovation in the cinematic viewing experience, namely a generative AI-based screen expansion function utilizing MR devices such as Vision Pro. It is anticipated that this research will generate new value in the film market.

The findings of this study will contribute to the emerging field of XR viewing methods and content, which are undergoing rapid development. The video viewing method on current XR screens offers a straightforward approach to integrating existing video screens with the XR environment. Notably, this study established that leveraging Generative AI to generate real-time images will enhance video content viewing experiences. Consequently, as research on Generative AI continues to evolve, it is anticipated that the approach employed in this study will contribute to future research in this field. The findings of this study are expected to facilitate the development of a positive user experience, particularly in the context of technologies such as XR and Generative AI. However, it should be noted that this research is subject to certain limitations, as the video generation AI model has not yet been commercialized. The experiments employed temporary production videos, rather than videos that expanded the actual movie screen, which hinders the ability to ascertain the impact on the actual user experience. Consequently, future research will seek to derive more detailed results by identifying problems that arise during the actual use of XR devices.

This research is subject to certain limitations, primarily due to the nascent state of commercialization of video generation AI models. Furthermore, the study employed temporarily produced experimental videos rather than expanding actual movie screens, which hinders a comprehensive assessment of the impact on real-world user experiences.

Consequently, subsequent research endeavors will prioritize the identification and mitigation of these limitations through empirical studies. These studies will investigate the challenges and usability issues that emerge from the practical application of XR devices, aiming to enhance the comprehensibility and practicality of the insights derived from these models. This methodological shift is expected to yield more detailed and applicable insights, thereby enhancing our understanding of AI-driven screen expansion in practical immersive media environments.

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