THE PRESENT IN THE FUTURE IS THE PAST: Applying Generative AI to Visualize and Imagine Cultural Heritage Sites in Both Augmented and Physical Reality

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Abstract

Visitors to Cultural Heritage (CH) sites are often only able to observe the current degraded state of these locations without the understanding of their history and personal connection possessed by local inhabitants. To facilitate expression of this intangible aspects of CH, we collected Generative AI (GenAI) created images of the past and future of CH sites from workshop participants, and displayed these images in Augmented Reality (AR) form, and as drawn by a physical drawing robot. The collected imagined CH images are shown in an AR app that uses markers on a large scale 3D map model of the city. The images are also drawn physically by a robot when visitors mention the names of the CH in answering questions to a chat query, serving as markers created in progress for the AR. Visitors found the experience engaging for illuminating intangible connections of people to CH sites. This work highlights the way GenAI-created images can be shown in AR and physical forms to empower imagination and expression for social purpose.

Keywords

Cultural memory, Cultural heritage, Augmented reality, Site-specific art, Place-based storytelling, Practice-led research, Temporal intersections, Futures, Participatory Art, Human and Non-human Agents

Introduction

Cultural Heritage (CH) is a crucial carrier of human history, providing us with essential pathways to understand our past and ourselves [12]. However, the current state of many CH sites is concerning, with significant historical information and cultural connotations gradually disappearing.

Much research effort has been directed towards fostering the engagement of local inhabitants in the re-creation of Cultural Heritage (CH), with a particular focus on their distinct experiences and interactions. [1, 28] This active involvement in the generation, sharing, and distribution of CH is a significant contributor to the evolution of CH. It allows for the customization of services and promotes two-way interactions with CH participants. [22] Furthermore, Raptis underscores the impact of individual cognitive variances on the experiences and outcomes of participants in CH activities. [27] These studies highlight the necessity of resident participation in the re-creation, sharing, and distribution of CH. Direct observation of the audience may not fully capture their personal CH experiences, narratives, and emotions. However, the advent of Artificial Intelligence Generated Content (AIGC) has proven to be an effective instrument for articulating these personalized interpretations. [1, 4, 24, 28]

AR and GenAI are significant developments in the field of technology in recent years, offering us new perspectives and methods to understand and experience cultural heritage.[10, 11]AR technology overlays virtual information onto the real environment, providing users with an immersive experience. GenAI, on the other hand, generates innovative and imaginative images by learning from a large amount of data, revealing the past and future of cultural heritage. In this work, we combine AR and GenAI. We collect images about the past and future of CH sites created by workshop participants, display these images in AR form, and draw them with a physical drawing robot. We hope that this approach can stimulate public interest and imagination about cultural heritage and enhance their connection with it.

Figure 1: The installation of GenAI-generated images of participants' visions of Cultural Heritage, with visitors at the exhibition site (left), the performance of the drawing robot (middle), and a screenshot of the AR effect on a mobile phone (right).

Amidst these considerations, our study sets out to address key research questions, including:

- How can AR and GenAI be effectively combined to provide a richer, more immersive cultural heritage experience for the public?
- What role do GenAI-generated images play in enhancing public understanding and appreciation of cultural heritage?
- How can we stimulate public interest and imagination about cultural heritage through AR and GenAI?

Background

Cultural Heritage

In the realm of contemporary cultural heritage (CH), institutions are actively pursuing innovative engagement strategies, necessitating a nuanced understanding of individual connections for a comprehensive exploration. Research on CH interaction, exemplified by Andrea Iosue's work on interactive museum spaces, fosters collaborative learning and integrates CH content with urban environments. [20] J. Floch's research on youth engagement through mobile and social storytelling applications echoes this concept. [13]

Bartolini's investigation into CH recommender systems enriches art and CH exploration by considering user location, interests, and preferences. [2] Psomada et al.'s advocacy for digital storytelling rooted in cultural and creative industries facilitates active audience engagement with urban CH. [26]Challenges persist in inclusivity and technology access in user and community involvement.

Insufficient CH development highlights technology's potential, observed in Nusran's use of digital games to transmit folk stories to tech-savvy youth. [21] Silvia de los Ríos Pérez leverages cloud technology for adaptive, personalized cultural experiences. [8]Augmented, virtual, and mixed reality (AR/VR/MR) technologies, discussed by Bekele et al., serve diverse educational and exhibition purposes, with challenges in accessibility and affordability limiting societal impact. [3]

Recent research explores functions of text and images within artificial intelligence-generated content (AIGC) tools for CH. Huang et al.'s investigation into augmented reality and Unity 3D for interactive engagement surpasses conventional digitization. [16] Pistora et al.'s CHROMATA platform integrates AI-powered multimedia analysis and 3D reconstruction, contributing to CH digitization and preservation. [25] Darda et al.'s exploration of AI's impact on culture and art underscores biases in computer-generated choreography, emphasizing the importance of audience attitudes towards AI in the arts. [7]

These studies collectively contribute to the evolving landscape of CH, showcasing expanding possibilities and complexities as AI and machine learning advance, revolutionizing CH beyond preservation.

Generative AI

Generative AI has shown promising potential in enhancing personal and professional creative expression, particularly in the context of cultural heritage. Specifically, in the field of art generation, generative AI has been used for digital cultural heritage preservation, old photograph restoration, and object removal. [31] It has also been applied to the generation of geometrically symmetric patterns, which are prevalent in cultural heritages such as Portuguese, Moroccan tiles, and Batik in Southeast Asia. [6] Additionally, generative AI has been explored in the documentation and management of the cultural heritage of the COVID-19 pandemic, demonstrating its potential to conceptualize emergent fields of cultural heritage and design exhibitions on relevant topics. [29] However, it's important to note that the use of generative AI in cultural heritage raises ethical considerations, such as privacy, consent, and misrepresentation of cultural context. [17, 29]Furthermore, the application of generative AI in the preservation of cultural heritage is still in need of international standards for methodological reproducibility and faces challenges related to the destruction of cultural artifacts due to geopolitical instability, natural disasters, and armed conflict.[19, 18]

The potential of generative AI in cultural heritage is vast, but it is essential to address ethical implications and ensure methodological reproducibility to preserve the authenticity and integrity of cultural heritages.

Augmented Reality

With the development of virtual reality (VR), augmented reality (AR)expands the application field and plays an important role. For art and design, AR offers more dimensional possibilities. Gilroy et al. used virtual reality technology to create an AR virtual tree that can respond to changes in audience emotion.[14] They conducted an early evaluation of the system from a technical perspective and in terms of the user experience. In terms of user experience, AR has a significant effect on improving user focus. Di Serio et al. demonstrated that augmented reality positively impacts student motivation by comparing students' focus and satisfaction with learning in a slide environment and an AR environment. [9] AR technology has been a well-publicized tool to promote museum visitor consumption. He et al. studied the use of AR technology in museums. They evaluated the positive effect of AR environments on increasing visitors' willingness to spend money shopping at museums. [15]

Augmented Reality is quite promising for cultural heritage. Park et al.pplied MR (AR/VR) technology to KCTM, a mobile application that showcases cultural heritage, providing users with a visual and dynamic personality experience.[23] Bozzelli et al. have applied AR technology to the ArkaeVision project, which aims to provide viewers with a different sensory experience in archaeology and cultural heritage.[5] Wang et al. utilized the characteristics and advantages of AR technology as the medium of the museum's mobile terminal platform to solve the current problems of the museum's site constraints, a single form of display, and an overly rigid display mode.[30] In conclusion, AR technology has very promising possibilities for the Multi-dimensional presentation of cultural heritage, creating new cultural heritage experiences, creating user interactive creative experiences, and promoting user consumption of artwork. Čopič Pucihar et al. explored a personalized art experience that appeals to young people through AR technology. [32]

Methods

Workshop Participation

During the initial workshop phase, we established the experimental protocols and subsequently issued a call for participation. The recruitment efforts targeted a cohort of 20 participants from China, comprising 15 females and 5 males aged

between 18 and 35. Each participant possessed limited familiarity with the cultural heritage of at least one city from a provided list, particularly one not regularly frequented (e.g., Hong Kong). Compensation for participation involved the provision of a comprehensive dissemination brochure. In adherence to ethical considerations, explicit consent forms were obtained from all participants. Additionally, to safeguard privacy, all collected data underwent anonymization with the participants' consent.

The experimental process unfolded by presenting participants with a booklet detailing the cultural heritage of Hong Kong, prompting them to select a location for their generative experiment. Prior to engaging in the creative process, participants underwent an initial interview where inquiries delved into their choice of location, personal impressions, expectations, and any emotional connections. The generative experiment was conducted using the Stable Diffusion AI design software, with participants crafting imagined images grounded in their initial perceptions and incorporating nuanced modifications based on personal imagination. The resulting depictions often amalgamated diverse art styles from different temporal periods, such as abolitionism and futurism, injecting heightened interest and design complexity into the works.

Moreover, participants imbued their creations with narrative elements, elucidating the historical and future trajectories of the selected cultural heritage through textual and visual information. For instance, one volunteer (P17) conceptualized Yau Ma Tei by drawing inspiration from historical information about a former temple, envisioning a flourishing hub of civilization due to its low-lying topography and abundant water resources. The final image depicted a water village along the river, showcasing the intriguing design process.

Figure 2: HK Fruit Market as image envisioned and created by P17 using Stable Diffusion.

The autonomy of volunteers in the absence of guidance or intervention during this creative endeavor enhanced the uniqueness of the design process. Following several hours of image generation, participants selected a final image and engaged in discussions regarding their design process, methodologies employed, and the intended expressive content, including the rationale behind their ideas.

Software Development

For the augmented reality experience in the exhibition, we used the game engine Unity3D 2019.4.3f1 combined with the AR software development kit Vuforia to develop application software for Android mobile devices. It used AI-generated images as markers for the AR camera to recognize and track. We provided a combination of 3D models with exceptional materials and animations as the visual experience the audience will get when scanning the markers with our application software. In the exhibition, we also provided a QR code so the audience could download and install the AR software on their phones.

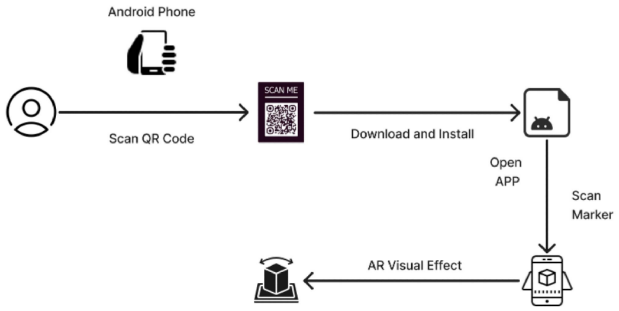

Figure 3: Flowchart of users downloading, installing and using AR mobile applications.

Design

Augmented Reality

For the installation of the 3D printed model, we first assembled the separate models with glue. Then, use a paddle and sandpaper to remove the impurities on the model's surface. Finally, we place the model on the display table and debug the projector to ensure the projection and the model can show the best effect.

In the AR experience, We printed out the markers generated with AI. Then, we used scissors to cut the markers carefully and paper tape to attach the markers near the corresponding models. In the exhibition, we provided a QR code so the audience could download and install the AR software on their phones. In addition to this, we also provide detailed tutorials about downloading and installing the AR app on Android phones to help viewers reduce unnecessary trouble.

Physical Reality

Image Curation The curation of photographs is meticulously derived from compelling perspectives captured during the experimental process, specifically extracted from the video documentation. Each selected image possesses distinctive characteristics, facilitating an intuitive comprehension of the volunteers' psychological states during the image generation. Furthermore, these images serve as a visual conduit for understanding the volunteers' intended expressions.

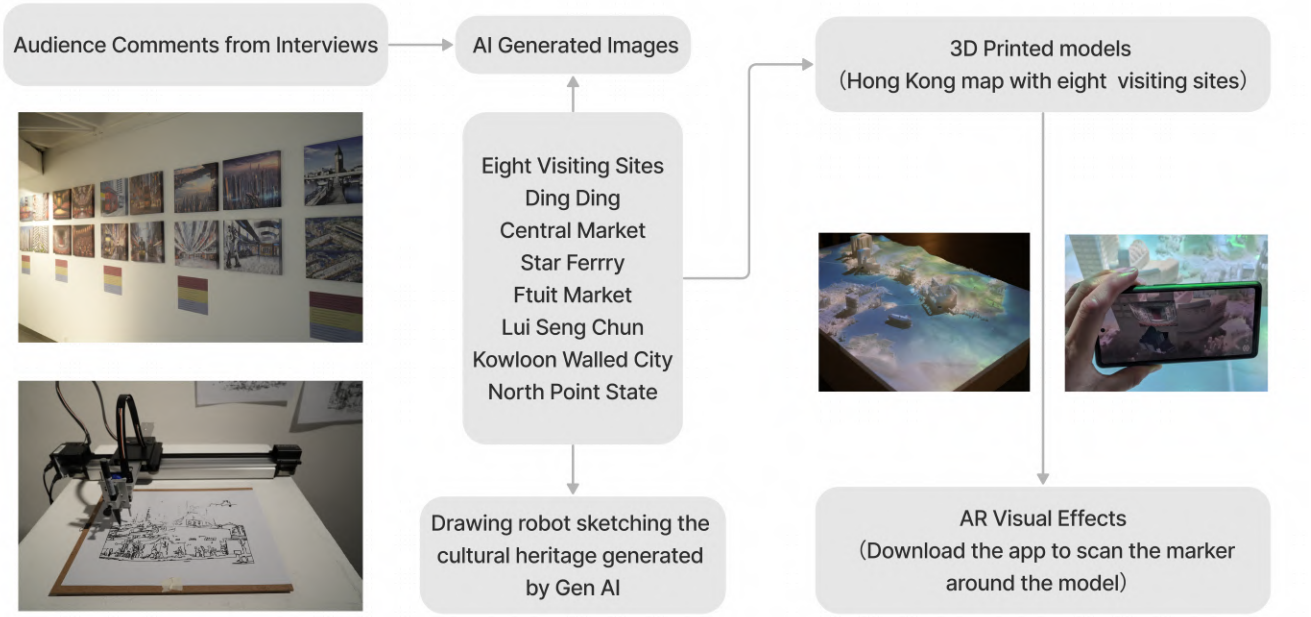

Figure 4: Diagram of the relationship between the systems components of the exhibition.

The array of images exhibits a commendable diversity, encompassing various styles ranging from realism to retro aesthetics, futuristic technological expressions, transcendent abstract representations, and depictions embodying the conflict of cultural symbol elements. Collectively, these images provide a nuanced reflection of contemporary public sentiments and cultural concepts. The creative fusion of cultural heritage as a thematic foundation and AI technology as a medium of expression culminates in the production of the 32 most exemplary images representing cultural heritage.

In essence, this creative endeavor not only yields a collection of visually captivating images but also serves as a vehicle for exploring the multifaceted tapestry of contemporary cultural contexts. The utilization of cultural heritage as a canvas and AI technology as a tool for expression results in a final output that not only resonates with the rich diversity of modern cultural nuances but also provides insightful glimpses into the collective consciousness of our contemporary society.

Drawing Robot In our exhibition, we implemented the Axidraw drawing robot to create an interactive and engaging experience for visitors. The setup begins with visitors replacing the paper in front of the drawing robot. To initiate the drawing process, they simply touch a designated spot on the exhibition table. This touch-based activation is based on the principle of skin conductance, using the touch as a switch to start the robot.

The drawing mechanism of the robot involves randomly selecting an image from a pre-stored collection. These images are generated by AI and then processed using Adobe Illustrator to convert them into Axidraw-compatible SVG format. These images are also used as markers for AR recognition.

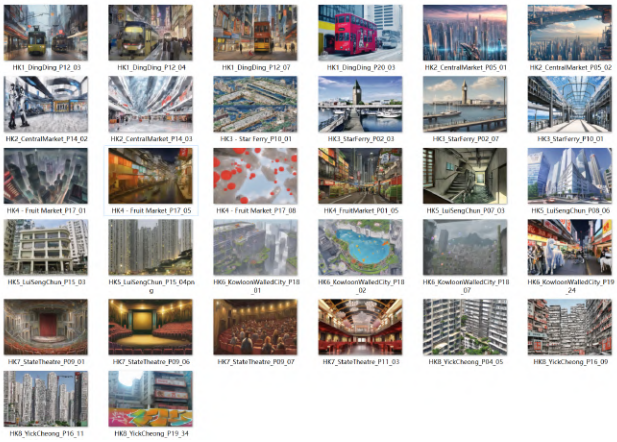

Figure 5: Selected 32 generated images.

As a result, visitors can scan these sketches with their smartphones to view a 3D representation of the cultural heritage buildings in augmented reality. This innovative approach combines the power of Generative AI, Augmented Reality, and physical drawing robots to create an immersive and educational experience for visitors, allowing them to explore and appreciate the intangible connections between people and cultural heritage sites.

Qualitative Findings

We interviewed audience members who visited the exhibition (n=8) to obtain insights about their perception about Cultural

Figure 6: Different facets of the AR exjperience. (Upper) A projection on a 3D landscape with embedded marker for using AR to show the 3D model related to each of the 8 CH sites. (Lower) A sketching robot drawing each of the CH sites in sketch form. The sketch itself serves as the marker for the 3D content in AR.

Heritage and compared how our interventions would affect this perception.

Dominance of Physical Interaction

Participants reported the physical interactions as the most rewarding part of the experience, in particular noting the physical installation with Hong Kong landscape projected on top, as well as the drawing robot. "*The robot can realize the actuality of the heritage experience because it's as if like [I am] drawing, and not just talking*" (P1). Moreover, "*it is nice to have a souvenir to take home as sketches*" (P5). The physical landscape also serves as a point of interaction, with some participants surprised to see the subsequent real physical space illustrated by the augmented representation.

Hidden Values of Neglected Heritage

Participants often told stories about the locations that we referred to in the exhibit, for example the Queen's Pier that no longer exists, or the abandoned places often explored by hikers, both of which do not exist in the same form today. "*Abandoned places have traces of humanity in them, and give us a vision of the remnants of the people at that time; even places that are gone leave a trace somewhere, they are not really gone*" (P2). Moreover, "Hong Kong city history is hidden away, and [we] cannot always find it" (P5). This idea of Cultural Heritage traces are seen in our exhibition photos as well, which included visions of the past, particularly the generated images of Kowloon Walled City, the Yick Cheong Building, and the North Point State Theatre, the latter of which can no longer be entered by the public. The nostalgia for the past was a common sentiment expressed by P2, P3, and P6.

Fostering Socialization Via Augmentation

The AR application was a source of frustration for the older visitors. Issues encountered included not having the right lighting to scan the code, not finding the right filter on IG, not having the updated software on the phone, etc. Interestingly during the whole experience, even when things do not appear to work, they facilitated a socialization process where each visitor helped others to try to get things to work (particular P4 and P2), or to share their working app experiences. The AR device then served to foster collaboration between strangers even when not always working perfectly.

GenAI Images as Bridges to the Imaginary

Visitors often mistook the GenAI-process-created images as physical paintings, because they were printed on canvas. "*When we walked in, [we thought] the images were real photos, and [it took some time] for us to realize they were not*" (P5). The introduction of the GenAI images were designed to take the visitor on an imaginary journey, and visitors appear also to be particularly fond of the images that do not depict reality, but rather show the extraordinary. "*Images of Kowloon City and the Monster Building were the most evocative, because they told of the city's past story and not the reality of today*" (P6). Thus, visiting the GenAI images appear to open up visitors' vision to facilitate imagination about hypotheticals in both past and future.

Discussion

Design considerations

We propose the design of art-creating tools that can help artists work with cultural heritage and help the audience relate more closely to cultural heritage to some extent. Combining the real and the virtual. Through our research, we found that due to individual differences, there are differences in each person's understanding and imagination about cultural heritage, and people's articulation of cultural heritage differs from reality. Therefore, creators can focus and connect individual stories to the future development of cultural heritage by creating a platform that combines real-world and virtual-world cultural heritage created through people's imaginations so that viewers can feel the difference between real and virtual cultural heritage. These interactions transform cultural heritage from a mere tourist stopover into a future space filled with personal imagination. Like Bozzelli et al.'s study of AR in cultural heritage, our research findings suggest that AR technology effectively provides audiences with different dimensions of cultural heritage experiences and positively facilitates audience linkage and interaction with cultural heritage.[5]

Combining robot sketching of cultural heritage with AR technology. Based on Park et al.'s research on AR cultural heritage mobile programs, we have innovated a design approach that combines robotic mapping of cultural heritage and AR technology.[23] In an era of rapid technology, robots drawing cultural heritage effectively demonstrate the combination of history, culture, and technology. It mainly reduced the unfamiliarity of viewers with unknown and age-old cultural heritage. With the combination of AR and machine painting, viewers can get 2D and 3D visual effects, providing a multi-dimensional experience and a creative interactive approach, which is beneficial in attracting viewers' interest

in cultural heritage and helping them to understand cultural heritage from more dimensions.

Limitations of the intervention and install

Cultural Heritage Engagement One limitation of the intervention and installation is that it heavily relies on the audience's prior knowledge and connection to the cultural heritage sites in Hong Kong. Visitors who are unfamiliar with these sites may not fully appreciate the significance and context of the generated images and augmented reality experiences. This could limit the overall engagement and impact of the exhibition for those who are not already familiar with the cultural heritage being explored.

Generative AI as Speculative Imagination While generative AI can produce innovative and imaginative images, there may be limitations in terms of accuracy, realism, and relevance to the cultural heritage sites. The AI-generated images may not always align with visitors' expectations or effectively convey the desired narratives and emotions. Some visitors may be unfamiliar with generative AI and augmented reality technology, which can impact their understanding and appreciation of the exhibition. The exhibition may require additional explanations or instructions to ensure visitors can fully comprehend and engage with the AI and AR elements. The use of AI technology raises ethical considerations, such as data privacy, bias in AI algorithms, and potential social implications. These ethical considerations should be carefully addressed to ensure the responsible and ethical use of AI in the context of cultural heritage.

Augmented Reality as Speculative Expression The use of augmented reality (AR) provides an immersive and interactive experience for visitors. However, the effectiveness of the AR experience may be limited by technical constraints and the accessibility of AR technology. Visitors who do not have compatible devices or are unfamiliar with the necessary software may face challenges in fully experiencing and engaging with the augmented reality component of the exhibition. The AR experience may be affected by different lighting and day conditions. Inconsistent lighting conditions can make it difficult for visitors to scan the AR markers and access the full functionality of the AR application. This can impact the overall quality and user experience of the AR component. The drawing robot used in the exhibition may encounter interruptions or technical issues, resulting in incomplete sketches or markers. This can affect the visual representation of the cultural heritage sites and disrupt the intended user experience.

Conclusions

This research project demonstrates the successful application of Generative AI and Augmented Reality (AR) to visualize and imagine cultural heritage sites. By collecting Generative AI-generated images of the past and future of these sites and displaying them in AR form and physical drawings, the project aims to enhance the understanding and connection to cultural heritage.

The qualitative findings from audience interviews highlight the positive impact of physical interaction, the discovery of hidden values in neglected heritage, the fostering of socialization through augmentation, and the role of GenAI images in bridging the imagination. These findings provide evidence for the effectiveness of the intervention and installation in engaging visitors and stimulating their perceptions of cultural heritage.

However, it is important to acknowledge the limitations of the project, such as the reliance on prior knowledge of the cultural heritage sites, the speculative nature of the AI-generated images, and the potential technical and accessibility challenges of the AR experience.

In conclusion, this research project showcases the potential of combining Generative AI and AR to create immersive experiences that foster a deeper understanding and appreciation of cultural heritage. The findings contribute to the ongoing efforts in cultural heritage preservation and emphasize the significance of leveraging technology for the sustainability of human civilization.

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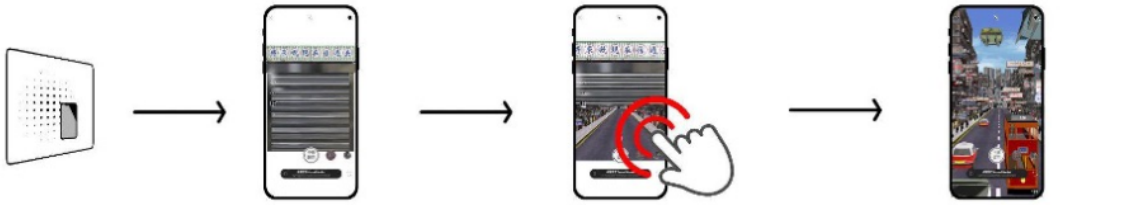
Launch AR filter on Instagram Target tracked Triggered effect 3D model launched

3D animated time lapse of "Central Market" played when target is tracked. With slider UI to contral the intensity of the effect.



Vertical plane is tracked AR portal is launched Tap screen to run the 3D animation Walk forward and look around

Kowloon walled city AR portal Monster building AR portal

Figure 7: AR Target tracking and interaction.