

Research Article

Enhancing Tourism in Takachiho through VR and AR Technologies: A Case Study on Virtual Scenic Experiences and Interactive Features

Satoshi Ikeda¹, Makoto Sakamoto¹, Amane Takei¹, Takao Ito²¹Faculty of Engineering, University of Miyazaki, 1-1 Gakuenkibanadai-nishi Miyazaki-shi, Miyazaki, 889-2192, Japan²Graduate School of Engineering, Hiroshima University, 1-3-2 kagamiyama Higashihiroshima-shi, Hiroshima, 739-8511, Japan

ARTICLE INFO

Article History

Received 15 November 2023

Accepted 27 August 2024

Keywords

Tourism technology

Virtual reality

Augmented reality

Visitor engagement

Cultural heritage

ABSTRACT

Miyazaki Prefecture faces several challenges in its tourism industry and has adopted various strategies to address them. In 2016, technologies like VR and AR gained attention. In response, our company developed a new smartphone app leveraging virtual technology, offering unique features to attract more tourists and encourage repeat visits.

© 2022 The Author. Published by Sugisaka Masanori at ALife Robotics Corporation Ltd.

This is an open access article distributed under the CC BY-NC 4.0 license

[\(http://creativecommons.org/licenses/by-nc/4.0/\)](http://creativecommons.org/licenses/by-nc/4.0/).

1. Introduction

The rise of mobile devices and interactive technologies has significantly impacted the tourism industry. To remain competitive and appealing, destinations must offer unique value and services. Takachiho Town, a prime tourist spot in Miyazaki Prefecture, is no exception. However, it faces challenges and requires new technological interventions to stay relevant [1]. In recent years, virtual technologies like AR, VR, and MR have gained recognition [2], [3]. This study focuses on addressing Takachiho's tourism challenges by implementing two virtual technology features: VR to enhance scenic experiences and AR to "take home" the tourist experience.

1.1. Background

Takachiho Town, situated at the northernmost tip of Miyazaki Prefecture in central Kyushu, is renowned for its rich natural beauty and historical significance. The

area is home to the breathtaking Takachiho Gorge and the ancient Akimoto Shrine, both shown in Fig. 1. The town experiences a dramatic change across the four seasons, enhancing its appeal as a nature-rich destination.

The history of Takachiho dates back approximately 6,000 years, with evidence of human settlement as early as 4,000 BC [4]. It is steeped in mythology, being the location where the gods are said to have descended, according to Japanese legends. This deep connection to Japanese mythology, including the famous Amano-iwato legend, makes Takachiho a place of great spiritual significance. In recent years, the town has gained attention as a popular "power spot," attracting visitors of all ages seeking both spiritual and physical rejuvenation.

The Akimoto area, also known as Okutakachiho, focuses on preserving traditional village life and offers tourists unique, immersive experiences. Visitors can enjoy local cuisine made with regional ingredients and explore sacred shrines and towering ancient trees amidst the majestic landscape. In 2016, this region was recognized by the Ministry of Agriculture, Forestry, and Fisheries as an exemplary "Treasure of Rural Mountain

Fishing Villages" [5], a title that is expected to further boost tourism in the coming years.

Despite its natural and cultural wealth, Takachiho faces challenges similar to many rural areas in Japan. Miyazaki Prefecture has noted a declining population, aging demographics, and increasing competition in the tourism sector. Additionally, advancements in information and communication technology (ICT) have not been fully leveraged to promote the area. As a result, tourist numbers have not returned to their peak levels [6]. To attract more repeat visitors, it is essential to create appealing tourist experiences and effectively utilize media, ICT, and social media platforms for promotion.



Fig. 1 Takachiho Gorge(left) and Akimoto shrine(right)

1.2. Applications of Augmented Reality (AR) in Tourism

One of the primary uses of AR in tourism is through mobile devices as interactive guide tools. AR acts as a bridge between tourist spots and visitors. For example, "ToARist: An Augmented Reality Tourism App created through User-Centred Design" [7] focuses on creating an AR app based on user feedback. This study identified what tourists truly expect from AR displays and how navigation through AR should be presented.

"Augmented Reality and Gamification in Heritage Museums" [8] analyzed AR communication models and their challenges in museum settings, concluding that adding gamified elements enhances user engagement and deepens the AR experience.

Another study, "How can Tourist Attractions profit from Augmented Reality?" [9], explored AR's profitability by collaborating with stakeholders. It presented a model showing that AR can be introduced to tourist sites with minimal financial risk.

A major example of AR in tourism is the success of "Pokémon GO," which had a significant impact on tourism. In November 2016, a collaborative event with Miyagi Prefecture attracted around 100,000 participants over 11 days, generating about 2 billion yen in tourism revenue [10]. Similarly, in Tottori Prefecture in November 2017, around 89,000 visitors attended over 3 days, generating 1.3 billion yen in spending and a PR value of 500 million yen [11] tourism marketing. "Virtual Reality and Implications for Destination Marketing" [12] examines how VR promotional content can positively

influence tourist spot perceptions, improving advertisement effectiveness and experience sharing.

Lastly, "Virtual Reality, Presence, and Attitude Change: Empirical Evidence from Tourism" [13] surveyed 1,000 participants on their experience with VR tourism content. The study revealed that VR significantly enhances consumer attitudes towards destinations, proving it to be an effective tool in tourism marketing.

2. Method

We will outline the method used to develop the application.

2.1. 3DCG Model Production

We collaborated with vocational schools in Miyazaki Prefecture to produce 3D models, as depicted in Fig. 2. These models include a depiction of the god featured in Kagura, the mascot of Takachiho, and a hawk native to the area.



Fig. 2 Bird's eye view of Tadikarao (upper left), hawk (upper right), "chihomaro" character (bottom)

2.2. System Overview

For the system, we used Unity 3D to develop applications compatible with mobile devices, focusing on future scalability and cross-platform functionality. The 3D models were created using Blender, and the application was run on Android smartphones.

2.2.1.1. VR Implementation

To achieve virtual reality (VR), we utilized a smartphone paired with Google Cardboard-compatible VR glasses. This setup allows users to explore a 3D recreation of Takachiho. Fig. 3 displays the VR glasses, and Fig. 4 shows the VR view of Takachiho.



Fig. 3 VR glasses.

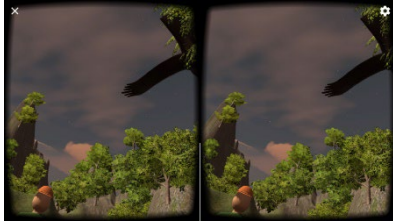


Fig. 4 VR Takachiho.

2.2.2. AR Implementation

We implemented markerless augmented reality (AR), which recognizes natural images (such as pamphlets or product packages) instead of markers. When the app detects a Kagura pamphlet, the god begins to dance, and recognizing the "Chihomaro" package brings the character to life. A special feature allows users to make the god dance in the palm of their hand by recognizing a hand gesture. Fig. 5 illustrates these AR experiences.

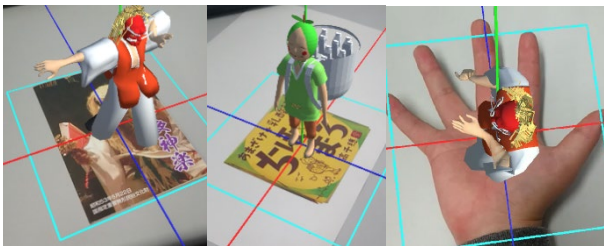


Fig. 5 Recognizing a pamphlet (left), package (center), hand for the dance (right)

2.3. Experiment

We conducted a trial of the application with five participants in their 20s. Each person interacted with the app for 3 minutes and then filled out a questionnaire covering six items (rated on a 1 to 5 scale) and one open-ended question. The questions focused on the virtual technology, content, and its connection to tourism.

3. Result and Discussion

The item "After experiencing virtual technology, do you want to visit the destination?" scored 4.2 points, indicating that virtual experiences can enhance interest in travel and make destinations feel more accessible. Similarly, the response to "Do you want to share the

contents of virtual technology?" was positive, showing that virtual technology, especially with easy-to-use VR glasses and markerless AR, encourages sharing.

While some participants still prefer physical travel over virtual experiences, AR offers unique opportunities, such as interacting with virtual characters and enhancing the overall visit through guided tours and photo opportunities. However, the responses to "Is it easy to prepare for virtual technology?", "Is the VR/AR easy to operate?", and "How rich is the content?" were less favorable. Challenges included the cumbersome process of setting up VR glasses and obtaining AR-recognizable images. The difficulty in achieving smooth hand recognition in AR also contributed to the negative feedback on operability. To improve, a key goal will be to develop fully markerless AR technology for smartphones.

4. Conclusion

In this study, we developed a tourism app utilizing both VR and AR technologies. The VR feature offers a virtual tour of Takachiho, while the markerless AR reads pamphlets and packages to display 3D models. A unique "Takeout" feature allows a 3D model to dance in the user's hand without needing a marker. The evaluation results indicated that incorporating virtual technology into tourism can increase both new and repeat visitors. By enhancing AR capabilities and allowing users to take photos with 3D models, we can offer more engaging experiences. Additionally, integrating gamification elements, like a stamp rally, could extend the app's use before, during, and after sightseeing.

Acknowledgements

We would like to thank Miyazaki Multimedia Vocational School for their cooperation in 3DCG modeling, and extend our gratitude to the Miyazaki Tourism Convention Association, Akimoto District residents, and others involved in this project.

References

1. Heisei27 July Miyazaki Prefecture "Tourism Promotion Plan ~ Toward revival of tourism miyazaki ~", [Online] <https://www.kanko-miyazaki.jp/downloads/media/3374>. [Accessed: 14-Sep-2024]
2. Takashi Kurida, Kiyoshi Kiyokawa, Takashi Okuma, "Fundamentals, Development and Practice of AR Technology", Science Information Publishing, 2015, pp 377-385.
3. Zenji Nishikawa, Katsuomi Kobayashi, Yaseinootoko, izm, Kazuya Hiruma, "VR contents development guide", MDN Corporation, 2017, pp18-33.

4. Ministry of Land, Infrastructure, Transport, and Tourism (MLIT), "Multilingual Database for Infrastructure Projects, 2018." [Online]. Available: <https://www.mlit.go.jp/tagengo-db/en/H30-01332.html>. [Accessed: 14-Sep-2024].
5. Takachiho Town Tourism Association, "Information on Village Tours in Takachiho, 2024", [Online]. Available: <https://takachiho-muratabi.com/news/info/533/>. [Accessed: 14-Sep-2024].
6. Miyazaki Prefectural Government, "Tourism Report for Miyazaki Prefecture, Jan. 2020", [Online]. Available: <https://www.pref.miyazaki.lg.jp/documents/84434/4832420200116130545-1.pdf>. [Accessed: 14-Sep-2024].
7. Williams, M, Yao, KKK and Nurse, JRC et al., "ToARist: An augmented reality tourism app created through user-centred design", *31st British Human Computer Interaction Conference*, 2017.
8. Ramy Hammady, Minhua Ma, Nicholas Temple, "Augmented Reality and Gamification in Heritage Museums." , *Serious Games*, Vol. 9894, Springer, Cham, 2017, pp. 181-187.
9. Eleanor E Cranmer, M. Claudia tom Dieck, Timothy Jung, "How can Tourist Attractions profit from Augmented Reality?" , *Augmented Reality and Virtual Reality - Empowering Human, Place and Business*, Springer, Forthcoming, 2017, pp. 21-32.
10. Travel Voice, "Impact of Pokémon GO on Tourism in Japan, Dec. 21, 2016", [Online]. Available: <https://www.travelvoice.jp/20161221-80223>. [Accessed: 21-Dec-2016].
11. Tottori Prefectural Government, Report on Regional Vitality Promotion, Dec. 2017. [Online]. Available: https://www.pref.tottori.lg.jp/secure/1098599/291201genki_houkoku_besatu.pdf. [Accessed: 1-Dec-2017].
12. Griffin Tom, Giberson Juleigh, Lee Seung Hwan (Mark), Guttentag Daniel, Kandaurova Maria, Sergueeva Ksenia, Dimanche Frédéric, "Virtual Reality and Implications for Destination Marketing", *Travel and Tourism Research Association: Advancing Tourism Research Globally*, 29, 2017,.
13. Iis P. Tussyadiah, Dan Wang, Timothy H. Jung, M.Claudia tom Dieck, "Virtual reality, presence, and attitude change: Empirical evidence from tourism" (2018). *Tourism Management* Vol 66, 2018, pp. 140-154.

Dr. Makoto Sakamoto



He received the Ph.D. degree in computer science and systems engineering from Yamaguchi University. He is presently a professor in the Faculty of Engineering, University of Miyazaki. He is a theoretical computer scientist, and his current main research interests are automata theory, languages and computation, etc.

Dr. Amane Takei



He is working as a professor for Department of Electrical and systems Engineering, University of Miyazaki, Japan. His research interest includes high performance computing for computational electromagnetism, iterative methods for the solution of sparse linear systems, etc. He is a member of IEEE, an expert advisor of IEICE, a delegate of IEEJ, a director of JSST.

Dr. Takao Ito



He is a professor of Management of Technology (MOT) in Graduate School of Engineering at Hiroshima University. He is serving concurrently as Professor of Harbin Institute of Technology (Weihai) China. His current research interests include automata theory, artificial intelligence, systems control, etc.

Authors Introduction

Dr. Satoshi Ikeda



He received PhD degree from Hiroshima University. He is an associate professor in the Faculty of Engineering, University of Miyazaki. His research interest includes graph theory, probabilistic algorithm, fractal geometry and measure theory.