

Science Tour and Business Model Using Digital Twin-Based Augmented Reality



Seungyoub Ssin, Minjeong Suh, Jongwook Lee, Timothy Jung,
and Woontack Woo

Abstract The purpose of this study is to propose a theoretical framework for a digital twin-based smart science tourism system using augmented reality in Gwanghwamun Square. To date, smart tourism service was not sufficiently developed for the provision of relevant tourism information to visitors as tourism contents were managed by the separated information system of each institution. The tourists could not receive ideal tourism routes based on their preferences and also according to congestion of each institution. Moreover, the business model using existing tourism services was not well developed, and thus the current tourism services have not sufficiently contributed to the revitalization of the regional economy. We designed a digital twin-based tourism content management system that provides integrated management of tourism information, and augmented reality (AR) science tour services which are included with contents recommendation, best path finding, contents sharing and gamification. We also adopted a business model using the AR tourism platform based on digital twin technology which could contribute to the invigoration of the local economy.

Keywords Digital twin · Smart tourism · Augmented reality · Business model

S. Ssin (✉) · W. Woo (✉)
KAIST ITC ARRC, Daejeon, Republic of Korea
e-mail: youb1649@kaist.ac.kr

W. Woo
e-mail: wwoo@kaist.ac.kr

W. Woo
KAIST UVR Lab, Daejeon, Republic of Korea

M. Suh · T. Jung
Creative AR&VR Hub, Manchester Metropolitan University, Manchester, UK
e-mail: t.jung@mmu.ac.uk

J. Lee
Department of Cultural Heritage Industry, Korea National University of Cultural Heritage, Buyeo,
Republic of Korea
e-mail: bellee21@nuch.ac.kr

1 Introduction

There are various museums, art galleries, science museums, and experience centers in and around Gwanghwamun Square. In particular, Gwanghwamun Square and its surroundings are valued as a place to experience the history and latest trends of science in Korea. There are many cultural organizations with science heritage contents in Gwanghwamun Square such as the Gyeongbokgung Palace, National Palace Museum of Korea (traditional science), National Museum of Korean Contemporary History (industrial science), National Museum of Modern and Contemporary Art (media art), National Children's Science Center, and corporate technology experience centers (ICT).

As science heritage contents are managed by the separated information systems of each institution, they were not integrated well and therefore tourists have difficulty accessing desired contents. In order for tourists, who are visiting Gwanghwamun Square, to receive tourism services on a single platform, the contents management systems must be integrated. However, science heritage contents are saved and managed as their own metadata; therefore, there are limitations to integrating, managing, and utilizing them (Patel et al., 2005). Furthermore, the existing tourism information systems and applications could not recommend tourism routes based on the individual tourist's preferences and the congestion of each institution, thereby failing to support convenient and pleasant visitor experiences. Moreover, the existing tourism services have struggled to contribute to the revitalization of the regional economy due to lack of business models linking to existing tourism services (Smirnov et al., 2014).

We propose a digital twin tourism content management system with metadata that provides integrated management of tourism information around Gwanghwamun Square. This includes digital twin-based content and route recommendation system that could provide customized contents as well as an optimal route recommendation service. In addition, we propose a business model with the science tourism platform based on digital twin technology that contributes economic activities in Gwanghwamun Square by integrating various contents online.

In order to achieve the aim of this study, following objectives were set:

1. It proposes a digital twin-based tourism content management system to integrate, manage, and utilize tourism contents that are managed by separate information systems,
2. It proposes a digital twin-based tourism business model that resolves information asymmetry and maximizes customer satisfaction through economic efficiency and data utility.

If a digital twin-based smart tourism platform is successfully implemented, then it is expected that this will encourage tourists to revisit Gwanghwamun and also contribute to sustainable growth of local tourism-related businesses in Gwanghwamun Square.

2 Literature Review

The Gwanghwamun Square, a space imbued with symbolism, has been a hub of politics, economy, culture, and tourism in South Korea since the fourteenth century. There are many cultural resources and organizations in and around Gwanghwamun Square (Shin & Zoh, 2013). In particular, the Gwanghwamun Square is in the central location of science heritage experience, where the National Palace Museum of Korea (traditional science), National Museum of Korean Contemporary History (industrial science), National Museum of Modern and Contemporary Art (art and technology), and corporate technology experience centers (ICT) are located. The historical contents of Gwanghwamun are managed together with the history of Gyeongbokgung Palace, but historical and cultural science heritage contents are managed separately by different institutions, which makes it difficult for tourists to understand and experience their historical and cultural connections. In order to address this issue, there is a need for state-of-the-art digital twin technology which can provide integrated management of these scattered historical and cultural contents (Jouan & Hallot, 2019).

Digital twins model the physical world and systems with the same structure in the virtual world and enable monitoring, simulation, information visualization, service validation, and service participation in the relevant physical space using various sensing technologies provided by IoT and 5G (Seungyoub Ssin et al., 2018). The technology was initially developed by General Motors (GM) to conduct detailed checks of their products, but it is now receiving much attention in other industries due to its ability to solve various industrial and social problems. Digital twin technology was initially used as an information visualization system for simulation in the manufacturing industry (Zuehlke, 2010). This led to the emergence of smart factories, which upgraded their existing facilities by combining automation technology and IoT (Lucke et al., 2008). Managers can now efficiently monitor maintenance and repairs, machine control, safety management, and error handling while manufacturers are capable of rational distribution, production planning, and simulation (Wang et al., 2016). The successful experiences of smart factories have laid the foundation for the establishment of smart cities that apply technology combining IoT, 5G, Cloud, Robot, AI, and AR/VR—the core elements of the Fourth Industrial Revolution—to the regeneration of old cities and the construction of new ones (Chen et al., 2017). In the tourism context, the power of digital twin technology in integrated management and simulation could provide an alternative solution for successful management of scattered tourism resources in a single integrated system.

An existing integrated tourism service called ‘Sejong Belt’ promotes cultural organizations and visitor attractions nearby Gwanghwamun Square (Ha, 2011). This is a tourism service that connects 15 theatres, including Sejong Centre for the Performing Arts and Seoul Namsan Traditional Theatre; five museums, including Seoul History Museum and the Bank of Korea Money Museum; and five art museums, including the Seoul Museum of Art and Gallery Hyundai, around Gwanghwamun Square. This service offers customised products and services according to price, target, time, space,

and theme through the Sejong Belt website and information Centre. However, this integrated tourism information system failed to provide customized service according to the preferences of individual tourists and also based on the congestion of each institution. Moreover, this service was developed from the perspective of suppliers and therefore it could not induce continuous participation of tourists. Digital twin-based tourism services enable tourists to receive continuous service by supporting authoring and sharing of tourists and recommending contents and optimized routes, based on consideration of individual preferences and congestion on a real-time basis.

Virtual reality is a technology that enables tourists to experience tourist destinations prior to their physical visit. Immersive contents based on virtual reality are widely used in the context of smart tourism (Lee et al., 2019). For example, Marriott hotels provide virtual tours of Rwanda and the Andes, to allow tourists to experience the surroundings. Augmented reality (AR) has the benefit of enriching experiences by enabling tourists to experience various media along with the tourist attractions on site, and many tourism contents using AR have been created. For example, in Korea in 2017, the KAIST Graduate School of Culture Technology UVR Lab developed the K-Culture Time Machine 1.0, a smart tour application to experience historic sites beyond time and space, using VR and AR (Kim, E. et al., 2016). This application connects to an external database to retrieve figures, places, events, and media related to historic sites based on ontology and provides such information to users. Moreover, it enables users to experience geo-spatial contents by restoring and reproducing lost cultural heritage sites and historical events. However, existing VR and AR tourism applications are not sufficiently developed for seamless service, as they are limited by the intentions of service providers which aim to merely deliver information. Furthermore, they do not provide convenient and beneficial tourism services such as real-time route information for tourists.

A business model is the basic framework governing how a company will do business, deliver value to customers, and generate profits. It is therefore used as a means to maintain competitiveness of the existing business, expand, and strategize new business. The US venture capital survey agency, CB Insight, revealed that the main cause of failure of start-ups was related to the business model (Nam, 2016). For example, Geevor Tin Mine Museum in England is the largest historic site related to mining in the UK and is located amid the dramatic landscape of the Atlantic Coast of Cornwall. Results of a survey on visitor experience of an integrated (VR&AR) environment showed the experience to have a crucial impact on revisits (Jung et al., 2016). However, the lack of pre- and post-marketing meant that the connection to the business model was somewhat inadequate. Linking the VR&AR experience with the business model will be more effective for pre- and post-experience marketing.

In conventional tourism, there is a close link between tourism products and consumers, and the growth of platform businesses along with technological development have brought the two into direct confrontation. A platform business in the tourism industry can be an 'integrator' like an online travel agency which delivers tourism products to consumers with an external platform business operator in the middle, or a 'two-sided' type like TripAdvisor or Yelp, with two main agents enhancing value by interacting on the platform (Lee et al., 2018). It is important

to create value as a business platform through commissions and advertisements, but there is limited research on how to use the data effectively. For example, it may be more useful to study recommendation services based on user data, i.e. finding optimal tourism routes by analyzing the previous tour data.

Tate Modern, a world-renowned urban regeneration project which successfully combined art and business, reinvented an abandoned factory as an artistic space. It has become a major tourist spot in the UK which attracts countless tourists (British Council, 2020). Tate Online is more than just a website for the art gallery; it also includes an online catalogue of the entire Tate collection as well as webcasting of lectures and events. In addition, it features the ‘Tate Papers’, an online academic journal; carries out online-only activities or exhibitions; and communicates with visitors on social media (Facebook, Twitter, etc.) (Lee, 2017). However, it needs to expand the role of its platform business, since it holds free exhibitions and does not make profits from admission fees. Its online shop has many products but lacks publicity. It is necessary to induce customers to participate in online product development or nurture talented local artists by expanding online exhibitions.

To conclude, a digital twin based platform combining various technologies such as AR/VR, AI, 5G, and IoT will have huge social impacts and also economic impacts due to the potential of business models generated by this new platform.

3 Proposition of Digital-Twin Based Tourism Platform and Business Model

We propose a digital twin-based science tourism service to enable tourists obtain seamless tourism services via integrated management of scattered science heritage contents and authoring and sharing of tourists. The Data section in Fig. 1 includes data generated from the existing database as well as data generated by location shifts after tourists generate media on their mobile phones. The generated media and data are sent to the data platform. In the Data Platform section, the collected tourism data is integrated and saved in the form of predefined metadata, and it enables numerical simulation to visualize data tables and predict tourism figures (e.g. congestion, tourism demand, movement information) in terms of data management. The Digital Twin section supports monitoring (e.g. determining the location of children in tourist sites), visualization of tourism data (e.g. floating population on a 3D map), tourism planning (e.g. finding optimal travel routes), simulation (e.g. predicting traffic jams), verification of real-time tourism information, and operation of tourism facilities.

Next, the AR Tour Platform section supports technology to provide precise location-based services and in-situ authoring, 2D/3D rendering of tourism information, context awareness to provide service that reflects user and environment data, and user interface support. AR services include recommendations of tourist spots for individual tastes related to science, finding the best routes to enjoy tours from a current location, tourism and authored data sharing with tourists nearby, and game services.

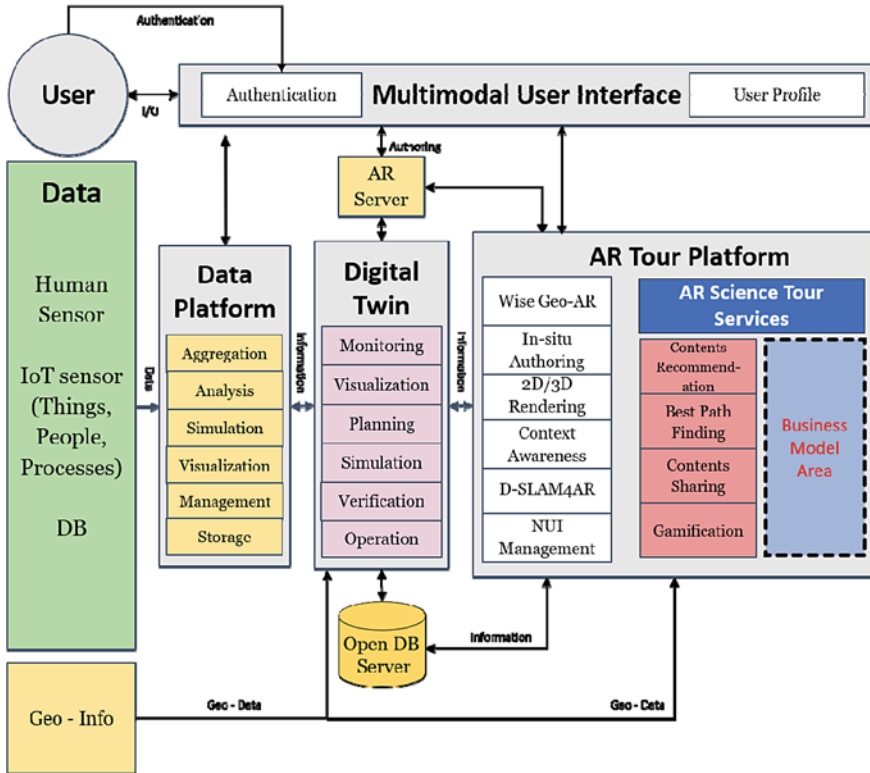


Fig. 1 Concept map of digital twin-based AR Science Tourism Service

Finally, tourists undergo the authentication process through multimodal interfaces such as smartphones and AR glasses to experience digital twin-based services suited to user information. Moreover, they create location-based contents and upload and share them on digital twins through the AR server. Tourist site managers can provide optimal services for tourists through various simulations on the data platform and digital twin.

In the concept map of the digital twin-based AR tourism service in Fig. 1, the data platform obtains data from the mobile devices of tourists, IoT sensors installed at tourist sites, and databases of cultural organizations, and then integrates, analyses, simulates, visualizes, manages, and saves the data. The digital twin collects information from the data platform and uses it for monitoring, visualization, planning, simulation, verification and operation. The AR platform prompts the AR server and open database server to provide AR/VR tour services through Wise Geo-AR, in-situ authoring, 2D/3D rendering, context-awareness, D-SLAM4AR, and NUI management. Tourists can receive services such as science heritage content recommendation, pathfinding, science heritage content sharing, and science heritage contents gamification.

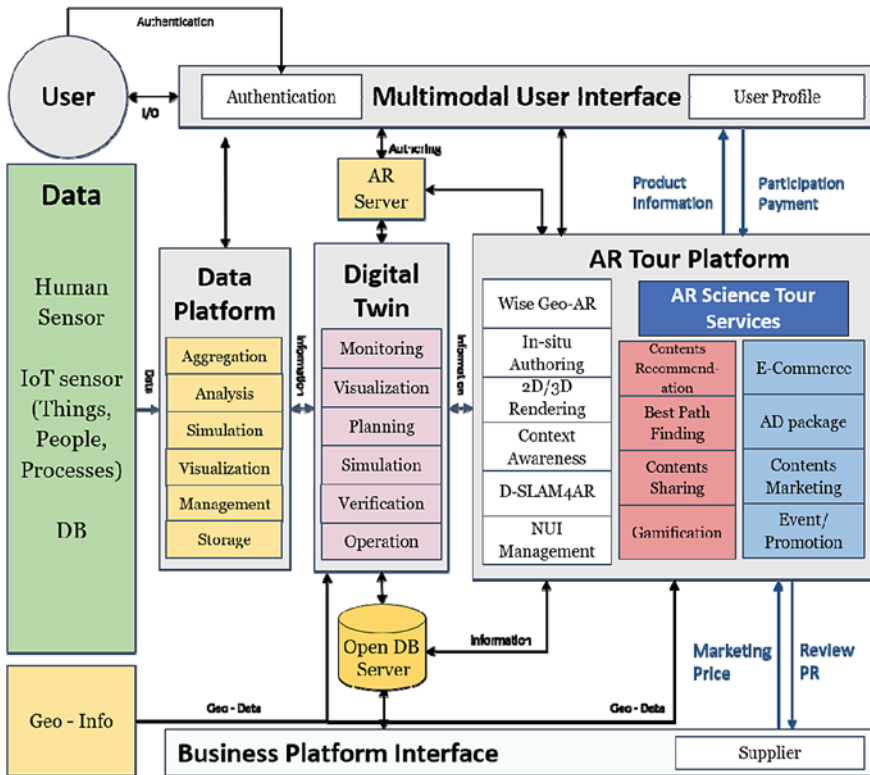


Fig. 2 Digital twin-based scientific tourism business model

The content sharing feature of AR Science Tour Services can resolve the digital divide among regions through immersive experiences of science tourism by supporting digital visualization technology online. Moreover, by combining and providing various tourism contents using features such as content recommendation and best path finding, the platform will increase tourist satisfaction and accessibility of relatively isolated tourist sites, thereby promoting economic activities in the surrounding areas. Finally, AR gamification with in-situ learning combined with location-based services induces an increase in the flow of content understanding through rewards and experiences to produce a scientific tourism business model (Fig. 2).

The digital twin-based tourism business platform provides products and information that meet the needs of visitors based on big data analysis of tourist’s behavior in connection with the AR Tourism Service. As a result of testing the AR tourism platform through Dublin tourists, the user’s interface design, easy navigation, and program speed were important (Han et al., 2013). Both large and SMEs (small and medium-sized enterprises) which provide tourism products or services can secure channels to promote and sell their products through the digital twin-based tourism

business platform, while they are holding sales promotions to sell tourism products. Moreover, they can establish a business ecosystem by analyzing data from customer reviews and providing feedback to businesses, as well as obtaining new customers by increasing customer touchpoints in connection with the external social media platform. This can contribute to the revitalization of the regional economy by increasing tourist satisfaction and offering quality information on products and services according to individual preference (Yu, 2017).

By applying the technology and business model described above, tourists can experience virtual artifacts in Gwanghwamun Square and recommend semantically related content through digital twin-based AR. The tourists decide the artifacts of interest through the AR experience, and the Digital Twin recommends the AR tourism route in consideration of the visitor's preferences and the congestion of cultural institutions. The tourists can watch virtual and real artifacts and upload their experiences to digital twins as well as share them on SNS. Digital Twins store and manage the tourist experience information and reuse it for content recommendations when they are returning. The tourists can access the digital twin through virtual reality to purchase tourist products based on the objects of interest after the tours.

4 Discussion and Conclusion

The digital twin-based smart tourism content management system provides customized services for consumers using metadata based on existing tourism resources. Customized contents and optimal route recommendation services even induce tourists to visit tourist attractions that had been relatively neglected due to the lack of information. Therefore, the newly proposed system would result in the balanced development of the regional economy and a ripple effect on the growth of tourism-related businesses. Furthermore, it also provides a high-quality business platform with increased tourist satisfaction by inducing understanding of contents and flow through rewards and experience.

We expect that it proposed a framework for digital twin-based AR science tourism services, which will contribute to the development of data management and utilization methods by using a metadata-based digital twin to integrate various contents. Besides, this study contributes to inducing revisits of tourists and revitalizing the regional economy by proposing an AR science tourism platform business model.

This study proposed a digital twin platform structure and content and path recommendation services based on this platform from the perspective of content managers of digital twin-based tourism services. Academically the study stimulates a discussion on the potential benefits and challenges of the new digital twin-based tourism service platform from the perspective's technical development as well as a business model in the context of science heritage tourism. Further research is required on user experience and VR/AR application interfaces from the perspective of tourists. Furthermore, we anticipate quantitative research and validity analysis on the suitability of the business model for digital twin-based science tourism services.

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