Mathematical Biosciences and Engineering

MBE, 20(5): 8745–8765.
DOI: 10.3934/mbe.2023384
Received: 30 December 2022
Revised: 18 February 2023
Accepted: 26 February 2023
Published: 07 March 2023

http://www.aimspress.com/journal/MBE

Research article

Proposal of smart guide system for cultural heritage of archaeological sites using IoT-focusing on Hoeamsa Temple site in Yangju, Korea

Heesoo Choi* and Sangheon Kim

Department of History content, Sangmyung University, 20 Hongjimun2gil, Jongno-gu, Seoul, Korea

* **Correspondence:** Email: choice@smu.ac.kr; Tel: +821041418094.

Abstract: Due to the nature of the cultural heritage guide of the archaeological site, it is necessary to effectively and quickly deliver a significant amount of information. In this paper, we propose a smart guide system for guiding the cultural heritage of outdoor archaeological sites. IoT has been greatly expanded in archaeological sites, but most of them are for checking and preserving the current status of cultural heritage. Therefore, research results were limited to the field. Therefore, in this paper, the smart guide system was reviewed as part of the expansion application of IoT technology in the field of cultural heritage. To this end, for example, the value of cultural heritage sites in Yangju, Korea was analyzed, the status of cultural heritage guidance in the historical site was reviewed, and a smart guide system using IoT was proposed. Through this, it is expected to be applied to the cultural heritage guidance system at the world's archaeological sites.

Keywords: smart guide; IoT; archaeological site; Hoeamsa Temple site; museum

1. Introduction

As the 4th industrial revolution is in full swing, the activation of information services using digital technology is accelerating. Now, it is a reality that the development of a technology called artificial intelligence is spurring. As such, the sharing and utilization of information have become commonplace. Based on this, the acquisition and utilization of various types of the industrially necessary information as well as life information necessary for individuals are being carried out through various methods. In addition, socially, there are an increasing number of cases in which specific contents of the entire region are acquired and used in the development of policies or

technologies necessary for the public sector. It is because new technologies related to information distribution using networks are appearing widely [1].

One of the most notable technologies is the Internet of Things (IoT). In the past, information services using computers or mobile devices were generally provided through service applications by basically manually integrating data. However, with the development and development of IoT technology, it is now possible to provide information through networks regardless of devices. IoT technology is also widely applied to the personal sector, industrial sector, and public sector as discussed above. However, until now, IoT technologies have been confined to the collection of data and the use of immediate response for convenience in life, industrial use, and public policy [2].

The possibilities of IoT are endless. In particular, it can be said that the possibility of utilization in terms of information service is very high, but it is still judged to be insufficient. The same goes for the guide to cultural heritage that we are going to examine in this paper. Cultural heritage is largely divided into two types according to the form of its existence. One is in the form of a relic, i.e., a garden, and is mainly stored in a museum or exhibition hall and is visible to the public. In the case of relics, information service is provided through a guide system within the museum-usually an audio guide or a mobile application for a tour guide [3]. However, in the case of remains in the open air, most information services are in the form of information boards.

Therefore, it is necessary to consider several circumstances when discussing digital technologies related to the guidance of tangible cultural heritage, such as ruins. Remains are generally composed of monuments, buildings, buildings, buried cultural assets, etc. Among them, archaeological relics often include many types of such relics. The value of cultural heritage is also not simple because archaeological sites are located in fairly large spaces and contain many types of cultural heritage. In addition, since most of the archaeological remains are handed down in an incomplete form, it is difficult to understand the complete form. Therefore, guidance and commentary on archaeological ruins need to convey a great deal of information, such as the complete appearance of the site, the value of each type of cultural heritage, and the historical and cultural significance of the whole. Therefore, the method of guidance is also insufficient to proceed with the installation of information boards. Nevertheless, most of the discussions on cultural heritage guidance using IT technology are centered on museums, and there are very few discussions on guidance on outdoor archaeological sites.

Therefore, it is necessary to consider some characteristics when discussing digital technologies related to the guidance of tangible cultural heritage. The ruins are generally divided into monuments, buildings, and buried cultural properties. Among them, archaeological remains include exposed and buried remains, and many different types of artifacts excavated there. The cultural heritage value of the archaeological site is also very complicated. In addition, it is difficult to understand the complete form because most of the archaeological remains are transmitted in incomplete form. So, the guide and explanation of the archaeological remains include a lot of information such as the complete appearance of the ruins, the value of each type of cultural heritage, and the overall historical significance. But, providing information through the guide board is bound to have certain limitations.

There are many cases of IoT technology application to archaeological sites, but the representative examples are as follows:

•Pompeii Archaeological Site, Italy-uses IoT sensors to monitor the site's microclimate and alert staff to potential threats like humidity and temperature fluctuations.

•Çatalhöyük archaeological site, Turkey-utilizes IoT sensors to measure environmental conditions, including temperature, humidity, and light levels, to help preserve the fragile archaeological remains.

•The Great Wall of China uses IoT sensors to monitor the condition of the wall, including temperature and humidity levels, as well as to detect any potential damage caused by earthquakes or other natural disasters.

•The Valley of the Kings, Egypt-has implemented an IoT system that tracks the location and movement of visitors to prevent damage to the fragile tombs and artifacts.

As shown in the above examples, the use of IoT in archaeological sites is mostly about status checks and monitoring for the preservation and management of cultural heritage [4–7]. Therefore, research results are also focused on the use of IoT technology for the preservation and management of cultural heritage.

There is also an example of a cultural heritage guidance system using IoT. One such example is the Museo dell'Opera del Duomo in Florence, Italy. The Museo dell'Opera del Duomo is a museum that houses works of art and historical artifacts related to the Cathedral of Santa Maria del Fiore, including the famous dome designed by Filippo Brunelleschi. In 2015, the museum underwent a major renovation that included the implementation of an IoT system to enhance the visitor experience. The system, called "Opera Laboratori Fiorentini" uses beacons and sensors to provide visitors with real-time information about the works of art and artifacts on display. The beacons, which are small Bluetooth transmitters, are placed near each object and send signals to visitors' smartphones or tablets, triggering multimedia content such as audio commentary, images, and videos. The IoT system allows visitors to learn about the history and significance of the museum's collection in a more interactive and engaging way. It also provides museum staff with data on visitor behavior and preferences, which can be used to improve the museum experience and better preserve the cultural heritage on display. This is just one example of how IoT technology is being used to provide guidance on cultural heritage, and it demonstrates the potential for technology to enhance the visitor experience while preserving and promoting our shared cultural heritage.

In this paper, we would like to propose a cultural heritage guidance system using IoT technology. Through this, we hope to increase the possibility of using IoT technology only for preservation and management, to establish a cultural heritage guide system that can properly provide the value of the complex and diverse cultural heritage of archaeological sites, and to establish a cultural heritage guide system tailored to users. Therefore, in this paper, we will look into the application of IoT for the guidance of cultural heritage of archaeological sites exposed to the outdoors. To do so, first, we will look at the current status of cultural heritage information in archaeological sites, and consider ways to guide cultural heritage using the Internet of Things, taking the example of the Hoeamsa Temple site in Yangju, Gyeonggi-do, Korea, which has the characteristics of an outdoor archaeological site.

2. Materials and methods

2.1. Current status of guides in archaeological sites

In the case of archaeological sites exposed outdoors, it is typical for a cultural heritage commentator to accompany and provide guidance at a specific point. Cultural heritage docent guidance is effective because detailed explanations are possible in a lively manner at the archaeological site. In particular, a guide from a docent with in-depth knowledge of the archaeological site is more fun than reading research papers, and is likely to be remembered for a long time. However, it is difficult to respond to visitors to the archaeological site as much as a person has to guide them directly. Although

there is always a certain number of docents in each archeological site, physical limitations are encountered during periods or times when a large number of visitors gather. For this reason, it is common for many historical sites to set a tour guide's guide time and lead a group of visitors according to the time. Even in this case, the inconvenience is that the docent's guidance is not evenly delivered to the visitors.

In order to solve these problems, the guide on cultural heritage seeks various methods. It can be divided into two types: one is when a museum or exhibition hall is built to provide guidance and commentary on cultural heritage, and the other is culture using digital devices (smartphones, smart pads, audio guides, etc.). It is the case for implementing guidance and interpretation of the property. In the case of the former, it is done in a physical space, and in the case of the latter, it is done in an online virtual space. The recent trend is the latter, especially cultural heritage information using smartphones is becoming more common. Let's review some examples.

There are various examples of guiding archeological sites through the establishment of museums or exhibition halls. The stonehenge exhibition hall of stonehenge in England and the Neanderthal Museum of Neanderthal in Germany are typical examples. In Korea, the royal tombs museum in Wanggung-ri, Iksan, the Daeseong-dong ancient tombs museum in Daeseong-dong, Gimhae, and the Ancient Tombs Museum in Mali Mountain, Haman are typical examples. These museums and exhibition halls are all built near the archaeological site and are in charge of providing guidance and commentary on the relevant cultural heritage. Here, we will look at the example of the Wanggung-ri relics exhibition hall in Wanggung-ri, Iksan.

On the other hand, cultural asset guidance systems using digital devices are also developing in places where it is difficult to secure space for museums or exhibition halls or problems such as enormous costs accompanying the construction of museums or exhibition halls. Representative examples include the London museum's street museum in the U.K. or the culture click service in Paris, France, in the case of overseas, and the guide service for the five palaces, including Seoul's Gyeongbokgung Palace and Changdeokgung Palace, and Jongmyo Shrine in Korea. A typical example is the Deoksugung AR-based guide service.

Deoksugung was originally a private residence. It was the home of Wolsandaegun, the older brother of Seongjong during the Joseon Dynasty, and it was the place where King Seonjo lived temporarily after Gyeongbokgung Palace was burned down during the Japanese invasion of Korea in 1592. King Seonjo stayed here for about 16 years. Later, Gwanghaegun called it Gyeongungung Palace, and it is also the place where King Gojong declared the Korean empire after Agwanpacheon in 1897 after entering the late Joseon Dynasty. An average of over 1 million visitors visit each year, and guides are provided by docents at set times.

Deoksugung Palace in Seoul is one of the five major palaces of Joseon. The five major palaces are Gyeongbokgung Palace, Changdeokgung Palace, Changgyeonggung Palace, Deoksugung Palace, and Gyeonghuigung Palace. Among them, Gyeongbokgung is the most important palace as the main palace of Joseon. Changdeokgung Palace and Changgyeonggung Palace were the spaces where the king stayed and handled state affairs for the longest period of time when Gyeongbokgung Palace was burned down during the Japanese invasion of Korea in 1592 and was the space where the king's family stayed. On the other hand, Deoksugung Palace, which existed as a temporary palace in the Joseon Dynasty, is a place where the decline of Joseon's national power at the end of the Joseon Dynasty, the proclamation of the Korean empire to overcome it, and efforts to maintain national sovereignty remain intact, and eventually became the site of national sovereignty invasion. Gyeonghuigung was a palace

that maintained its existence throughout the Joseon Dynasty, but during the Japanese colonial period, it was dismantled by the Japanese and its annexes were scattered here and there.

Deoksugung Palace, elevated from a private residence to a palace during the Joseon Dynasty, was originally called Gyeongungung Palace. In 1895, after the Eulmi incident, in which the queen was brutally murdered by Japanese assassins, King Gojong did not stay in the palace but lived in the Russian legation. This incident is called Agwanpacheon. After returning to Gyeongungung Palace in 1897, King Gojong established Hwangudan and changed the name of the country to the Korean empire and ascended to the throne. This is the reason why Gyeongungung Palace is a space for the restoration of national sovereignty. However, before that dream could be realized, Japan concluded the Eulsa treaty in 1905 and deprived the Korean empire of diplomatic rights. In 1907, Emperor Gojong sent an emissary to The Hague to appeal to the international community for this injustice. The signing of the Eulsa treaty and the dispatch of emissaries to The Hague were all conducted at Jungmyeongjeon Hall in Gyeongungung Palace.

The Japanese government, taking responsibility for the Hague emissary incident, forced Gojong to abdicate and enthroned Sunjong, while moving the emperor's residence from Gyeongungung Palace to Changdeokgung Palace. At this time, Sunjong changed Gyeongungung Palace, where King Gojong stayed, to Deoksugung Palace. It came from the heart of praising his father's virtue and wishing for a long life. For this reason, Deoksugung Palace became a space symbolizing the tragedy of Joseon and the Korean empire in the late Joseon Dynasty. However, it is also a space for the proclamation of the Korean empire and efforts to maintain its status as an independent nation among the great powers. Deoksugung Palace is a place with such historical significance.

The Cultural Heritage Administration has developed a service that guides the five palaces, which are Korea's representative tourist attractions and cultural heritage, through smartphones. The previously developed mobile guidance system did not give satisfaction to the visitors visiting the site. The reasons are, firstly, the inconvenience of having to pay a separate fee for using a special terminal, and secondly, there are cases in which visitors do not understand the contents properly due to the hard and difficult composition of the contents. Third, with the rapid development of IT technology, there was a phenomenon in which existing services easily became obsolete. Fourth, even if a personal terminal is used, there is an inconvenience of having to download a large amount of data. Due to these reasons, there have been cases of being turned away.

In order to solve these problems, Deoksugung AR-based guide service utilizes smartphones, while utilizing AR technology based on cultural heritage recognition and planning a new cultural asset guide service using storytelling. In order to solve the problems of the existing mobile guidance service, a guidance service was developed by combining location-based AR, image recognition AR, and image tracking AR technologies. In particular, image tracking AR overcomes the limitation that existing VR or AR cannot be mixed with real image information and applies the camera overlay function. Most of the past mobile guidance services had many inconveniences in that they played content by recognizing markers. However, here, markerless technology is applied to implement 2D and 3D virtual space data such as space, people, and cultural assets [8].

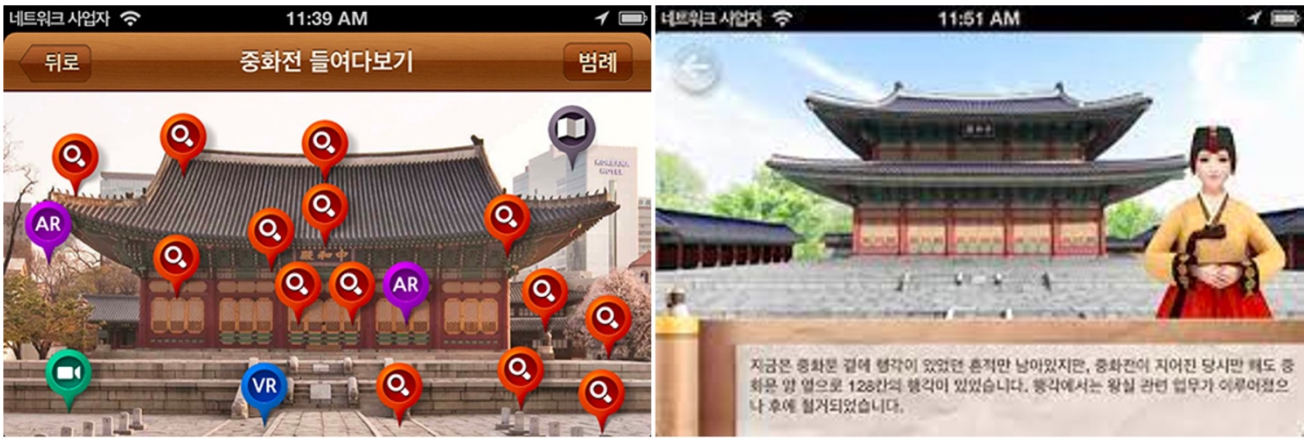

Figure 1. Palace guide system.

The content is largely composed of three parts: an introduction to Deoksugung, an outing to Deoksugung, and my Deoksugung. Deoksugung introduction is a menu that introduces the general contents of Deoksugung. The key menu is the Deoksugung outing. It consists of three modes: a general mode that provides docent guidance as a subordinate, a character mode featuring virtual reporters and King Gojong, and a quest mode with gamification added. Through this, the cultural heritage value of Deoksugung Palace was well recognized and enjoyed by the visitors. This method is a step forward from the existing guides for museums and exhibition halls. In particular, it has the characteristic of reinforcing on-the-groundedness in that contents can be acquired on-site while traveling around cultural heritage sites. However, there is still an inconvenience in that the visitor has to move while manipulating the mobile application. In addition, among the areas restored with AR, the Seonwonjeon area was not implemented at all.

In the above, examples of cultural heritage information using museums and exhibition halls and cultural heritage information using mobile technology have been examined. In many cases, museums and exhibition halls are being promoted to guide visitors to cultural heritage. If you use a museum or an exhibition hall, it is a great advantage that you can fully explain the cultural heritage based on the rich contents of the exhibition. In addition, it has the advantage of resolving the labor shortage caused by the docent operation and allowing visitors to gain knowledge related to cultural heritage regardless of the period or time of the visit. However, above all, there are huge obstacles such as administrative procedures that must be followed to establish a museum or exhibition hall, securing a site, a huge budget, and various problems related to management after opening. Nevertheless, the construction of museums and exhibition halls in the vicinity of many cultural assets has been carried out and will continue in the future. As such, the proportion of museums and exhibition halls is increasing.

However, cultural heritage information and explanations through museums and exhibition halls have certain limitations. First is the problem of sense of place. Because guidance and commentary are conducted in a space far from the site, it is difficult to properly perceive the sense of realism. The second is the problem of circularity. In the case of museums or exhibition halls, restoration of the site is realized through diorama models or digital content. In that case, there is no choice but to have limitations in that the scale or location cannot be accurately confirmed.

Even in the case of a mobile guide service, whether it is a marker recognition method or a markerless method, the user has to directly manipulate the application and call the content, which is

inconvenient. In particular, what can be the most problematic in the mobile guide service is that it is inevitable to move along the set storytelling under the compulsory flow structure set in the content. It is likely to result in a fixed cultural heritage perception. Therefore, it can be said that a system that can guide cultural heritage at the site of the archaeological site is absolutely necessary. What can be reviewed for this is the smart cultural heritage information service using the Internet of Things. The Internet of Things is an efficient method that can provide the visitor's flow and essential information at the relevant point without user manipulation.

2.2. Cultural heritage value of Hoeamsa Temple site as an archaeological site

There are many fields where IoT can be used. The field of cultural heritage is no exception. Among cultural heritages, it is difficult to provide information related to various cultural heritages in real space for historic sites with a large area exposed to the outdoors. Therefore, it is considered that the smart cultural heritage docent system using the Internet of Things is an appropriate solution. Archaeological sites exposed to the outdoors have various cultural heritage values. For this reason, the commentary on archaeological cultural heritage contains a lot of content. There are two, one is the explanation of the archaeological itself. This is centered on the history and origin of the archaeological site, as well as the remains and relics discovered as a result of excavation. The other is an explanation of the historical and cultural value of the archaeological site, which includes information related to the cultural exchanges contained in the archaeological site, figures related to the archaeological site, and sociocultural characteristics, etc.

Hoeamsaji, located in Yangju, Gyeonggi-do, Korea, is known as a temple built during the Goryeo Dynasty. Although the exact year of its foundation is unknown, it is believed that it had already been built around the 12th century at the latest, as there is a record that an envoy from China's Jin Dynasty visited here in 1174, and that there is a record that Taego Bou monk left the priesthood in 1313. Later, it is said that Jigong, an Indian monk, entered Goryeo and built it in 1328, the 15th year of the reign of King Chungsuk of Goryeo, but it is not certain. The definite record related to the construction of Hoeamsa appears in the <Cheonbosan Hoeamsasujogi> written by Lee Saek, a military official of the Goryeo Dynasty. As can be seen from the expression rebuilt, it means that Naong rebuilt an existing temple, so Hoeamsa Temple can be said to have existed before.

Even in the Joseon Dynasty, Hoeamsa Temple was maintained prosperously with the support of the royal family. Naong, the founder of the Joseon Dynasty, is the teacher of Muhak, the teacher of Yi Seong-gye, the founder of the Joseon Dynasty. For this reason, Master Muhak also stayed at Hoeamsa Temple, and Yi Seong-gye also lived at Hoeamsa Temple after stepping down from the throne. During the reign of King Seongjong, construction was carried out to expand the temple by order of Queen Jeonghee, the consort of King Sejo, and during the reign of King Myeongjong, with the help of Queen Munjeong, Hoeamsa Temple became the best temple in the country in name and reality [9].

Unlike Goryeo, which regarded Buddhism as important, Joseon, a Confucian country, socially rejected Buddhism. In the 21st year of King Myeongjong (1566), there is a record of Confucian scholars attempting to set fire to Hoeamsa Temple, and in the 28th year of King Seonjo (1595), there is an article about a large burnt bell at the former site of Hoeamsa Temple.

Judging from the records of King Seonjo, the Hoeamsa Temple was destroyed by fire around the 16th century, and records show that it was closed in the late 17th century. In other words, Hoeamsa Temple, which prospered with the royal patronage in the early Joseon Dynasty, rapidly

declined after the reign of King Myeongjong, with royal patronage ended, and was closed shortly after.

The Yangju Hoeamsa Temple site was excavated from 1998 to 2012, and the central area of the temple was excavated and investigated 10 times. As a result of the excavation, it was confirmed that Hoeamsa Temple had an architectural style similar to that of a palace, unlike other temples, and valuable artifacts such as pottery and roof tiles, which were used only for the royal family, were excavated in large quantities, confirming its status and aspect as the largest temple in the early Joseon Dynasty.

Figure 2. View and drawing reference of Hoeamsaji.

Through the excavation of the Hoeamsa Temple site, a detailed overall picture of the temple was revealed. First, looking at the overall structure, eight stone steps were confirmed in a stepped fashion. The building sites were arranged in a left-right symmetrical format with the north-south as the central axis. In particular, the Sangwon area centered on Bogwangjeon coincided with the contents of <Cheonbosanhoeamsasujogi> left by Lee Saek, resulting in a coincidence between historical records and excavation results. There are a total of 46 names of the halls in <Cheonbosan Hoeamsa Sujogi>, including Bogwangjeon, Gwaneumjeon, and Mitajeon where Buddha was enshrined; The halls can be classified according to various purposes such as warehouses and government offices. Through the names and uses of these halls, we can confirm the overall aspect of Buddhist temples in the late Goryeo Dynasty and the early Joseon Dynasty.

The appearance of 70 or so buildings tightly packed inside reminds us of the appearance of palace buildings. It can be seen that the buildings of Hoeamsaji were built in a closed form like the palace buildings in that they are built in a very closed form due to the characteristics of the palace architecture. In addition, various facilities to maintain such a large number of buildings were built with the best technology of the time. As a result of the current excavation, more than 35 spheres were found in a total of 70 building sites, which can be said to be the largest ondol site in Korea. Similarly, the drainage system, in which sewage pipes are dug into the ground or exposed to the outside, is a mixed drainage system [10].

In addition, in the case of Bogwangjeon, the most central hall of Hoeamsa Temple, there is Woldae (the stylobate built higher than other buildings), which can only be seen in buildings such as the main hall of palace buildings, suggesting its status as a royal temple in the early Joseon Dynasty. According

to records, there were events such as holding Buddhist ceremonies or entertaining monks at Hoeamsa Temple in 1373 during the reign of King Gongmin, 1376 during the reign of King U, and 1391 during the reign of King Gongyang of Goryeo. It can be seen that he had a close relationship with the royal family, such as performing at Hoeamsa Temple.

The artifacts excavated from Hoeamsa Temple also reveal the status of Hoeamsa Temple as a royal temple in the early Joseon Dynasty. Among the roof tiles excavated, sumaksae roof tile with the inscription of Prince Hyoryeong, the second son of King Taejong and older brother of King Sejong, was found at the Bogwangjeon site. And blue tiles, which were used in palaces and some royal palaces because expensive niter at the time was used, are also found at the site of Daejangjeon. On the other hand, the wind chimes hanging under the eaves of the building were found engraved with letters indicating the names of Muhak Daesa, Taejo Yi Seong-gye, and Crown Prince Yi Bang-seok. It shows the dignity of the Hoeamsa Temple at the time [11].

As seen in the case of the Hoeamsa Temple site in Yangju, outdoor archaeological sites contain the value of a fairly wide and diverse cultural heritage. For this reason, many archeological sites are currently preparing devices to guide cultural heritage. It is done in two main directions. One is to provide guidance through the establishment of a museum or exhibition hall. The other is when guidance is provided through the Internet or a mobile network. In the next chapter, we will look at this situation.

3. Results

Current exhibitions, the information provided, and events at the Hoeamsaji site are as follows.

3.1. Hoeamsaji museum

After the excavation of the Hoeamsa Temple site, a comprehensive maintenance plan was established to preserve the ruins and remains, and it was opened in 2012 as part of the project. Yangju Hoeamsa temple site museum sheds light on the history and status of Hoeamsa Temple, which was the largest royal temple in the late Goryeo and early Joseon Dynasty, and fulfills its role as a museum through the collection, storage, research, exhibition, and educational functions of relics. It consists of a permanent exhibition room and a special exhibition room. Hoeamsa Daegaram exhibition is a restoration model and video showing the size and value of Hoeamsa Temple, the largest royal temple in the late Goryeo Dynasty and early Joseon Dynasty. At the visitor center, visitors to the Hoeamsaji museum can check information on the ruins around the Hoeamsaji and take a history quiz to experience interesting knowledge. In the special exhibition room, royal family and Buddhist culture exhibitions related to Hoeamsaji are held once or twice a year. The Hoeamsaji museum manages the Hoeamsaji ruins together, providing related festivals and experiential learning. The value of Hoeamsa Temple is conveyed through the royal culture festival or the media facade of Hoeamsa Temple.

Figure 3. Hoeamsaji museum.

Figure 4. Hoeamsaji restoration diorama.

In the experience room next to the permanent exhibition hall, you can experience content that reproduces the old appearance of Hoeamsaji in VR. It is a content that allows you to simply experience the splendid old appearance of Hoeamsa Temple, which consists of more than 100 magnificent buildings.

Figure 5. Hoeamsaji museum VR.

3.2. Hoeamsa site information facility

Figure 6. Layout of Hoeamsa Temple site.

The floor plan of Hoeamsa Temple site shows the elevation of the presumably restored Hoeamsa Temple site at the place where the information board was installed. You can see the current and original appearance overlapped by engraving a restoration drawing on the transparent information board. It allows you to check your appearance without a special digital device.

AR-look is an AR-based viewing scope installed at the Hoeamsaji observatory. AR-look installed at the Hoeamsa Temple site restored 120 buildings at the Hoeamsa Temple site as well as the royal procession. It is installed on the observatory located at the top of the Hoeamsa Temple site, so you can see the details of the building and the people. Installed in 2019, it helps visitors understand the site's original appearance.

AR-look provides clear images in dark situations by applying screenshot taking and night mode as well as zooming in and out.

Figure 7. AR-look picture Hoeamsa AR-look.

3.3. Events at Hoeamsaji

3.3.1. Hoeamsaji museum media facade

Hoeamsaji museum utilizes the outer wall of the museum building to provide a media façade. Through the system installed in 2021, the audience participation program <Me Media Facade> and the museum story content <Little Monk Meets the New Hoeamsa Temple> are permanently running. This content expanded the museum experience space to an outdoor space, extended the experience time by operating it after sunset, and contributed to enhancing understanding of the Hoeamsaji ruins by using it as a visitor experience program.

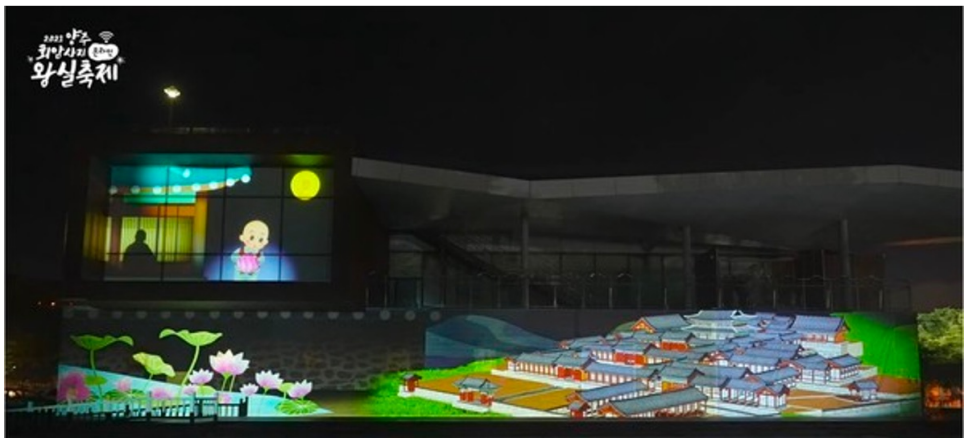

Figure 8. Hoeamsa media façade.

3.3.2. Hoeamsaji royal festival

The Hoeamsaji royal festival is a festival planned with the motif of the activities of King Taejo Yi Seong-gye, who stayed at Hoeamsaji after his abdication. It is held every year from late April to early May in the Hoeamsaji site. In 2019, starting with the Eoga (King's Chariot) procession, various performances and experience programs were held in the Hoeamsaji area.

Figure 9. Hoeamsa royal festival.

4. Discussion

4.1. Proposal of smart guide for Hoeamsa Temple archaeological sites

To apply IoT technology to the Hoeamsa Temple site in Yangju, contents containing the cultural heritage value of the Hoeamsa Temple site must first be placed throughout the Hoeamsa Temple site. The value of Hoeamsaji cultural heritage can be summarized in several ways as mentioned above.

The first is a guide to the entire temple. This includes the issue of Buddhism-related exchanges with China, the arrangement of Buddhist temples at Hoeamsa temple site, the explanation of the size and structure of the Hoeamsa Temple site, and the appearance of ruins that reveal the status of the Hoeamsa Temple site. First of all, the arrangement of Buddhist Temples with the characteristics of Southern Zen and Linji Buddhism in China, such as the Song Dynasty and the Yuan Dynasty, is applied to the Hoeamsa temple, confirming the exchange between Chinese Buddhism and Korean Buddhism. It will be able to compare the appearance of stipulating the layout of Buddhist Temples in Chinese Namjong Seon and the restoration of Hoeamsa Temple site. In addition, the scale and structure can be explained by implementing the restored shape of the Hoeamsa Temple in virtual reality or augmented reality. In addition, it can reveal the appearance of the unique building or traces that represent the shooting of Hoeamsa Temple by comparing it with the palace architecture [12].

The second is a guide related to the figures related to the temple as a whole. The figures related to Hoeamsaji are largely divided into two categories, one is those related to the establishment and operation of the temple, and the other is those related to the patronage of the temple. The former are monks such as Jigong, Naong, Muhak and Bou, and the latter are kings or royal figures such as Taejo Yi Seong-gye, Prince Hyoryeong, and Queen Munjeong. Since specific spaces related to these cannot be designated, they must be included in the description of the entire temple.

The third is a guide to the detailed appearance of the temple. Among the total of 70 building sites, the location and use of 46 building sites whose names and uses are known can be shown. You will be able to explain the names and contents of the buildings listed in the records, such as Buddha hall, Dang, Ryo, Chim, House, Sil, Gate Tower and Corridor, Warehouse, Cheong, Rim, etc. In particular, if you add content here, you can recreate the actual life of a temple by adding images of monks, kings, and royalty in the late Goryeo Dynasty and early Joseon Dynasty. In addition, it can be composed by reproducing the appearance of spheres and drainage channels to explain that the best architectural technology of the time was applied.

Fourth, Hoeamsaji can explain the different characteristics of other temples. This can be explained based on the unique artifacts excavated from the Hoeamsa Temple site. First, the relationship between the Hoeamsa Temple site and the royal family can be guessed through the tiles engraved with the names of the royal family. Next, through the excavation of Cheongwa, which was used only in palaces or temples of the royal family, it is possible to know how actively the royal family supported Hoeamsa Temple at the time. It can explain why ornaments such as Japsang (figures made of tiles placed on the eaves of a tiled roof) and Pungtak (A small bell that is hung from the eaves of temple halls, wooden pagodas, etc., or from the roof stone of stone pagodas, and shakes in the wind to make a sound) that used only in palace architecture were used in Hoeamsa Temple site. The above information is summarized in the table below [13].

Table 1. Smart guide content status and suggestion.

Place	Object	Details	Suggested guide place	Suggested guide type	Current status
Entire temple site	Cultural Exchange with China	Structure of Seon sect temples	Hoeamsaji entrance	image	museum display
	Size of the temple	Woldae structure, building scale		VR/AR	image at entrance
Entire temple site	Related monks	Jigong, Naong, Muhak, Bou	Hoeamsaji Observatory	image	museum display
	Related royal figures	Taejo, Hyoryeong, Queen Munjeong		image	museum display
	Temple arrangement	Hoeamsaji temple Arrangement		VR/AR	VR at observatory
Excavation area	Temple area	Classification by region	Area entrance	image/AR	museum display
	Building site	Name and use of each building site	each building site	image/AR	VR at observatory
	Gudle	Names and uses of Gudle	Gudle Excavation Point	image/AR	X
	drain	Drainage type and principle	Drain excavation point	image/AR	X
Excavation area	Roof tile/Blue tile	meaning of roof tile and inscription	Excavation point	image/VR	VR at observatory
	Japsang/Pungtak	Japsang, Poontak meaning		image/VR	VR at observatory

4.2. Design of cultural heritage information system

In general, several factors are essential when designing a guide system for archaeological sites using IoT technology:

•Sensors: IoT sensors collect data on various environmental conditions, such as temperature, humidity, light, and air quality. They can also be used to detect movement or the presence of visitors,

and trigger multimedia content or alerts.

•Beacons: Beacons are small Bluetooth transmitters that send signals to visitors' smartphones or tablets, triggering multimedia content such as audio commentary, images, and videos. They can be placed near objects or exhibits to provide visitors with more information and context.

•Connectivity: IoT devices require a reliable and fast internet connection to transmit data and interact with visitors' devices. This can be achieved through Wi-Fi, cellular networks, or other types of connectivity.

•Data management and analytics: IoT technology generates a large amount of data, which needs to be managed and analyzed to extract insights and improve the visitor experience. This can include data on visitor behavior, preferences, and feedback, as well as environmental data and other metrics.

•User interface: A user interface is necessary to display multimedia content and provide visitors with a way to interact with the IoT system. This can be a mobile app, a website, or other types of interfaces.

•Content creation: To provide visitors with engaging and informative multimedia content, you will need to create high-quality audio, images, videos, and other types of content. This can be done in-house or by hiring a professional content creation team.

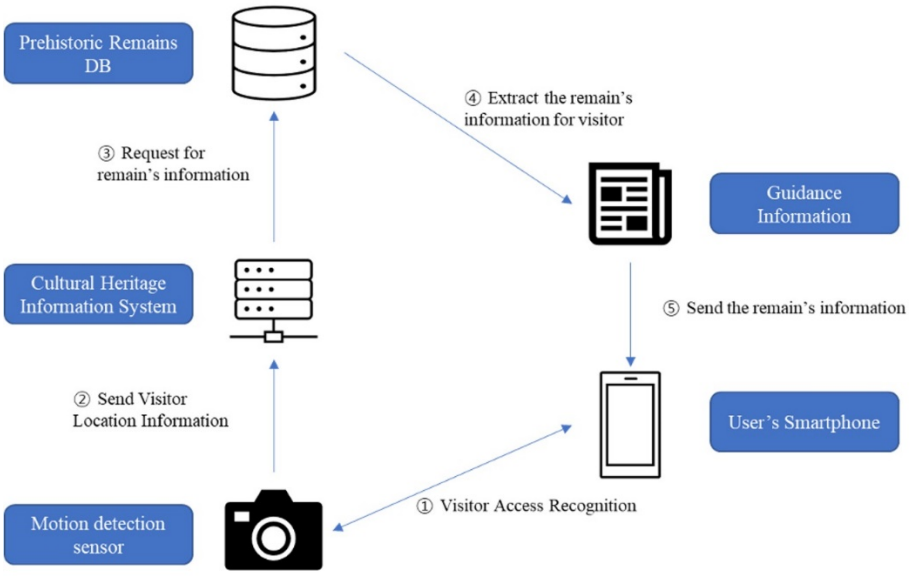

Figure 10. On-site guide system configuration.

Considering these factors, a motion sensor can be used in the Yangju Hoeamsa Temple site's cultural heritage information system. This sensor is attached to the information board for cultural properties and signposts on the route of viewing cultural properties, and the information corresponding to each visitor's stay or movement is provided through the visitor's mobile phone. Visitors can conveniently view the ruins because they provide automatic guidance without any additional operation. This IoT is provided through the connection between the visitor's cell phone sensor and the motion sensor of the information board for cultural properties.

The contents provided at Hoeamsaji are provided in various ways. However, in order to increase the effectiveness of such content, it is important to provide an integrated and consistent experience.

Suppose it is possible to provide information that integrates the information provided by the open-air site and the museum. In that case the visitor can obtain more intuitive and accurate information on-site and increase the satisfaction of the experience [14]. To this end, a method of combining previously provided content through user movement and movement is required [15].

As suggested in <Table 1>, information on a unit remains such as gudle (Korean style hypocaust) drain is provided in museum exhibitions, but if such information can be confirmed on site, visitor satisfaction can be further enhanced. For this purpose, the following system configuration can be considered.

There are several stages that visitors may go through during a visit to a museum, which can be generalized as follows:

•Orientation: This stage involves visitors getting their bearings and becoming familiar with the museum and its layout. They may use maps, guidebooks, or signage to navigate the museum and find their way to specific exhibitions or areas.

•Exploration: During this stage, visitors begin to explore the museum in more detail, moving from one exhibition or area to another. They may spend varying amounts of time at each exhibit, depending on their interests and preferences.

•Engagement: In this stage, visitors begin to engage more deeply with the exhibitions and artifacts on display. They may read information panels, listen to audio guides or attend guided tours, and interact with interactive exhibits or other multimedia displays.

•Reflection: At this stage, visitors may take a step back to reflect on what they have seen and learned. They may discuss the exhibits with friends or family members, make notes or take photographs, or simply sit and contemplate what they have experienced.

•Departure: The final stage involves visitors leaving the museum and completing their visit. They may visit the gift shop or café, provide feedback on their experience, or simply exit the museum and continue on with their day.

It is important to note that not all visitors may go through all stages of the museum visiting process, and the order and duration of these stages may vary from person to person. Nonetheless, understanding these stages can help museum staff design and plan exhibits and programming that engages visitors at each stage of their visit and promotes a meaningful and memorable experience.

Based on the description provided, a cultural heritage information guide for the Hoeam Temple Site IoT application could include the following information:

•Overview of Hoeam Temple site: An introduction to the Hoeam temple site, including its location, history, and cultural significance.

•Guide to the entire temple: A description of the entire temple site, including its size, layout, and structure. This guide could include a comparison of the layout of Buddhist Temples in Chinese Namjong Seon and the restoration of the Hoeamsa Temple site, and could be presented using virtual and augmented reality applications.

•Figures related to the temple: A description of the figures related to Hoeamsaji, including the monks who were involved in the establishment and operation of the temple, as well as the kings and royal figures who patronized the temple. This guide could include information about the specific spaces related to these figures, and could be presented using images and videos related to the late Goryeo Dynasty and early Joseon Dynasty.

•Detailed appearance of the temple: A guide to the detailed appearance of the temple, including the location and use of 46 building sites whose names and uses are known. This guide could explain

the names and contents of the buildings listed in the records, such as Buddha Hall, Dang, Ryo, Chim, House, Sil, Gate Tower and Corridor, Warehouse, Cheong, Rim, etc. Additionally, this guide could include images and videos related to the architectural technology of the time, such as spheres and drainage channels.

•Characteristics of Hoeam Temple site: An explanation of the different characteristics of the Hoeam Temple site from other temples, based on the unique artifacts excavated from the site. This guide could include information about the tiles engraved with the names of the royal family and the excavation of Cheongwa, which was used only in palaces or temples of the royal family. Additionally, this guide could include information about ornaments such as Japsang and Pungtak that were used only in palace architecture and were used in Hoeamsa Temple site.

Each component of the cultural heritage information guide could be presented using a combination of text, images, videos, and interactive media, such as virtual and augmented reality applications. This would allow users to experience the cultural heritage of the Hoeam Temple site in multiple contexts, and would provide a comprehensive guide to the site's history, architecture, and cultural significance.

The following is an algorithm to suggest the visitor's route:

```
function suggestPath(visitorInfo):

    // Step 1: Collect visitor information
    visitorInterests = visitorInfo.interests
    physicalAbility = visitorInfo.physicalAbility
    timeConstraints = visitorInfo.timeConstraints

    // Step 2: Analyze visitor interests
    if visitorInterests == "architecture":
        path = prioritizeArchitecture()
    else if visitorInterests == "figures":
        path = prioritizeFigures()
    else:
        path = prioritizeKeySites()

    // Step 3: Consider physical ability
    if physicalAbility == "limited mobility":
        path = avoidStairs(path)
    else:
        path = optimizePath(path)

    // Step 4: Optimize for time constraints
    path = optimizePathTime(path, timeConstraints)

    // Step 5: Prioritize key sites
    path = prioritizeKeySites(path, visitorInterests)
```

```
// Step 6: Suggest a path
displayPath(path)

// Step 7: Provide alternative paths
displayAlternativePaths()

// Step 8: Update path based on feedback
if feedbackReceived:
    updatePath(path)
```

The algorithm for suggesting a visitor path at the Hoeam Temple site appears to be a comprehensive and effective method for providing a tailored visitor experience that meets the needs and interests of each individual visitor. The algorithm takes into account several factors, such as the visitor's interests, physical ability, and time constraints, and uses this information to prioritize key sites and suggest an optimized path through the temple.

One potential strength of this algorithm is that it allows for a high degree of customization and personalization. By collecting and analyzing visitor information, the algorithm is able to suggest a path that is tailored to the specific needs and interests of each individual visitor. This can help to create a more engaging and rewarding experience for visitors, and can increase their satisfaction with the site.

Another strength of this algorithm is that it is flexible and adaptable. By providing alternative paths and updating the suggested path based on feedback, the algorithm can adjust to changing visitor needs and preferences over time. This can help to ensure that the path remains relevant and useful to visitors, and can improve the overall visitor experience.

However, one potential limitation of this algorithm is that it may require a significant amount of data collection and analysis in order to be effective. Collecting information about visitor interests, physical ability, and time constraints can be time-consuming and may require additional resources, such as surveys or questionnaires. Additionally, the algorithm may need to be modified or updated over time as visitor needs and preferences change, which could require ongoing maintenance and development.

Overall, the algorithm for suggesting a visitor path at the Hoeam Temple site appears to be a promising method for providing a tailored and engaging visitor experience. With careful planning and implementation, this algorithm has the potential to improve visitor satisfaction and enhance the cultural heritage experience at the temple site.

5. Conclusions

In the development and utilization of content for cultural heritage, numerous research and development processes must be repeated until the production of content, the final product. In addition, the process needs to be newly defined according to the use of the content.

Hoeamsa Temple site is trying to show the value of various cultural heritages centering on ruins and museums [16]. However, in order to effectively show historical sites in a wide area, it is desirable to add content and services that could not be provided in existing exhibitions through the application of smart guides.

In this study, the value of Hoeamsaji was considered, the current situation was derived through

analysis of the currently available content, and a plan to maximize value provision was presented through the use of various smart media. Digital heritage can be experienced through the smart guide to show it as close to its original appearance as possible without damaging the original artifact. It is a way to visually check the research results.

The guidance system proposal of this study has several advantages. First, by guiding cultural heritage using IoT at archaeological sites, it is possible to guide lively cultural heritage that museum exhibitions do not have. Second, it is possible to easily guide the cultural heritage values of archaeological sites in incomplete form or of very complex importance depending on the location. Third, by using the Internet of Things, it is easy to obtain only information necessary for unnecessary device operation and movement of visitors. Fourth, as visitors' usage patterns are accumulated, it is easy to upgrade the guidance system in the future through big data analysis. Fifth, although it is an example of Korea, the same system can be applied to archaeological sites around the world.

On the other hand, it also has limitations. First of all, the proposal does not have a specific case. But I think the possibilities are good enough. Next, it is difficult to implement the personalization function unless it has demographic statistics or sociological analysis information in advance. It is also thought that this can be solved through prior information analysis.

In the development of cultural heritage content, a circulation structure of research, knowledge contents, and utilization must be secured. Therefore, a long process of accumulating results step by step along the course of research is inevitable.

The application of new media should aim to identify new experiences centered on content rather than technology, and through this, it would be reasonable order to consider new content and new experiences.

Acknowledgments

This Research was supported by Sangmyung University Research Fund (2020-A000-0057 and 2021-A000-0131).

Conflict of interest

The authors declare there is no conflict of interest.

References

1. H. S. Choi, S. H. Kim, A content service deployment plan for metaverse museum exhibitions—Centering on the combination of beacons and HMDs, *Int. J. Inf. Manage.*, **37** (2017), 1519–1527. https://doi.org/10.1016/j.ijinfomgt.2016.04.017
2. M. K. Han, Internet of Things standardization trends and strategies, *J. Korean Inst. Commun. Sci.*, **38** (2021), 32–29.
3. S. H. Yeon, Y. W. Lee, J. I. Kim, A completement method for cultural place guiding system using regional geo-spatial image, in *Proceedings of the Korean Contents Society's Academic Conference*, (2005), 330–334.
4. M. Gribaudo, M. Iacono, A. H. Levis, An IoT-based monitoring approach for cultural heritage sites: The Matera case, *Concurrency Comput.*, **29** (2017), 26–45. https://doi.org/10.1002/cpe.4153

5. A. Melro, L. Oliveira, A. C. Amaro, Conceptualization of a dialectic between an Internet of Things system and cultural heritage, in *Information and Knowledge in Internet of Things*, Springer, (2021), 407–424. https://doi.org/10.1007/978-3-030-75123-4_18
6. A. Perles, E. Pérez-Marín, R. Mercado, J. D. Segrelles, I. Blanquer, M. Zarzo, et al., An energy-efficient internet of things (IoT) architecture for preventive conservation of cultural heritage, *Future Gener. Comput. Syst.*, **81** (2018), 566–581. https://doi.org/10.1016/j.future.2017.06.030
7. Y. Wu, Q. Li, H. Tong, Z. He, J. Qu, B. Zhang, Monitoring the deterioration of Masonry relics at a UNESCO world heritage site, *KSCE J. Civ. Eng.*, **25** (2021), 3097–3106. https://doi.org/10.1007/s12205-021-1716-z
8. S. H. Oh, K. D. Kim, Study on establishment of Deoksugung Palace, tourist information services using Augmented Reality (AR) technology, *MUNHWAJAE Korean J. Cult. Heritage Stud.*, **46** (2013), 26–45.
9. B. H. Hong, The architectural influence from the Yuan Dynasty and the acceptance of Goryeo Dynasty in the 14th century, *J. Archit. Hist.*, **25** (2016), 7–14. https://doi.org/10.7738/JAH.2016.25.5.007
10. Y. J. Kim, *Hoeamsaji Museum Series V: Architecture of Hoeamsa Temple*, 1st edition, Yangju Hoeamsaji Museum, Gyeonggi-do, 2017.
11. J. Y. Kim, *Hoeamsaji Museum Series II: Hoeamsa Temple and Royal Culture*, 1st edition, Yangju Hoeamsaji Museum, Gyeonggi-do, 2015.
12. S. D. Oh, The timing of relics at the site of Hoiam Buddhist Temple in Yangju and their effects on buddhist temples in Joseon through their analysis, *J. Buddhist Art*, **28** (2019), 101–125.
13. J. H. Park, *A study on the types of Digital Heritage*, Ph.D thesis, Sangmyung University in Seoul, 2021.
14. I. S. Jeong, S. W. Baek, E. S. An, Y. J. Kim, J. W. Choi, J. S. Yun, IoT-enabled solutions for tour photography services, *J. Korea Soc. Comput. Inf.*, **25** (2020), 127–135.
15. V. D. A. Kumar, G. Saranya, D. Elangovan, V. R. Chiranjeevi, V. D. A. Kumar, IOT-based smart museum using wearable device, in *International Conference on Innovative Computing and Communications*, Springer, **55** (2019), 33–42. https://doi.org/10.1007/978-981-13-2324-9_5
16. J. I. Kim, Strategies and challenges for the nomination of Yangju Hoeamsaji Temple site on the world heritage list, *Rev. Archit. Build. Sci.*, **61** (2017), 32–35.