Tourism Management and Technology Economy (2024)
Clausius Scientific Press, Canada

DOI: 10.23977/tmte.2024.070213
ISSN 2616-2199 Vol. 7 Num. 2

Application of Remote Sensing and Computing in Smart Archaeology and Tourism—A Loulan Perspective

Danling Chen[1]

[1]*Dongguan Institute of Surveying and Mapping, Dongguan, 523000, China*

Keywords: Remote Sensing; GIS; Loulan; Archaeology; Tourism

Abstract: With the rapid growth of urban informatics science and technology nowadays, the intersection of smart archaeology and tourism is still a brand-new field. Taking the perished ancient kingdom of Loulan as an example, this paper proposes the possibility of employing the technology and method of urban sensing and computing to play some role in the archaeology and tourism of Loulan. Loulan was an ancient kingdom, northwest China, dating back more than 2,000 years, which presumably disappeared owing to climatic change. This paper has successively proposed the use of deep learning algorithms to interpret ancient documents, the use of digital twin platforms to regenerate ancient ruins, the use of smart Internet of Things systems to enhance scenic services, and the use of augmented reality technology to display diverse travel experiences. The various methodologies utilised in this research have been preliminarily applied in the archaeological work of Sanxingdui and the digital reconstruction of Notre Dame de Paris, and their feasibility is established. In addition, the study outlines some of the existing challenges faced by this concept, such as the difficulty in rebuilding the ecological environment of the desert oasis, and the unpredictable risks that tourism would face. The technologies and methods proposed in this proposed application can also be implemented in other archaeological and tourism industries. The latest urban informatics technology will undoubtedly bring great subversion to traditional industries.

1. Application Scenarios

1.1 Proposal Background

In recent years, many tourist attractions including cultural artefacts and historical locations have changed their appearance. The combination of inventive ideas and modern technologies has made tourism no longer the boring form of taking buses, climbing mountains, and visiting ancient structures in the past(Association, 2021). For example, the Palace Museum is likely the first and most popular IP. It mixes the collections of the Qing Dynasty with cosmetics and cuisine in daily life, making the Palace Museum culture resurrected in the information age(Sun Yaqin, 2021). Another example, Sanya × "Peace Elite" once again propelled Sanya's tourism to a pinnacle(Daily, 2021).

Based on the lack of cultural tourism products in Northwest China, the opportunities brought by the Belt and Road Initiative, and the endless emergence of new smart technologies this year, this

project proposes to use urban informatics technology to help Loulan's archaeology and tourism construction, and try to revive Loulan culture[1-3].

Loulan, an ancient city remnant in the Western Regions of China, is located in the north of Ruoqiang County, Bayingoleng Mongolian Autonomous Prefecture, 7 kilometres distant from the northwest corner of Lop Nur and the south bank of the Peacock River. It was originally seen in "Records of the Grand Historian" and was once the only site to go on the Silk Road. Back then, Lop Nur was rich in water and vegetation, and Loulan Kingdom was affluent in commerce. Now there are only relics left (Fig1). It was founded before 176 BC and died in 630 AD, enjoying a history of more than 800 years(Mischke et al., 2017; Wikipedia, 2022).

Figure 1: Mural paintings signed Tita in the Loulan (Wikipedia, 2022)

1.2 Application Target

Due to the ancient country of Loulan's significant historical position and unmistakable brilliance, it is extremely important to revive and promote the ancient Loulan culture through archaeology and tourism. This plan, which is divided into three steps chronologically, makes use of deep learning, digital twins, the Internet of Things, augmented reality, and other technologies to propose solutions in all aspects of Gu Loulan, from archaeology to tourism development[4-7].

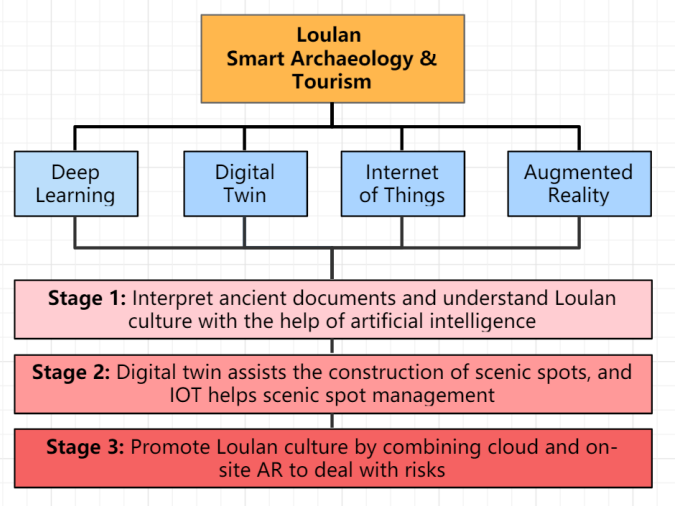

Figure 2: Proposed application structure diagram (Author's)

The project plan incorporates commercial and non-commercial components and, in an ideal

world, would involve collaboration between government agencies, scientific research institutions, businesses, and the general public. The plan is implemented in three phases, each of which is considered chronologically and also in order of complexity. In principle, and depending on the circumstances, social financing can be carried out in the 1&2 stage. Following the previous stage's profit, the profitable funds can be used to roll into the subsequent stage (Fig2).

The purpose of this project is to utilise cutting-edge technology to aid archaeologists, popularise ancient culture among modern people through new era tourism, enrich the tourism experience in the information age, and develop a cultural tourist attraction with unique characteristics of the Western Regions, thereby reviving the dead Loulan culture in a new form.

2. Technologies and Methods Used

2.1 Deep Learning Decipher Ancient Documents

Archaeological evidence indicates that the Loulan people's official script is Kharoshthi. Kharoshthi is a member of the Phoenician alphabet's phonetic script, which evolved from the Aramaic script. When Kharoshthi fell out of favour in Afghanistan and elsewhere, it was adopted by ancient Chinese kingdoms such as Khotan, Shanshan (Loulan), Shule, and Qiuci(Mischke et al., 2017). In terms of the quantity of Kharoshthi slips and tablets discovered thus far, the materials discovered, China, are the most numerous, systematic, and complete. To be certain, a comprehensive interpretation of Kharoshthi materials is necessary to fully comprehend the connotation of Loulan culture (Fig3).

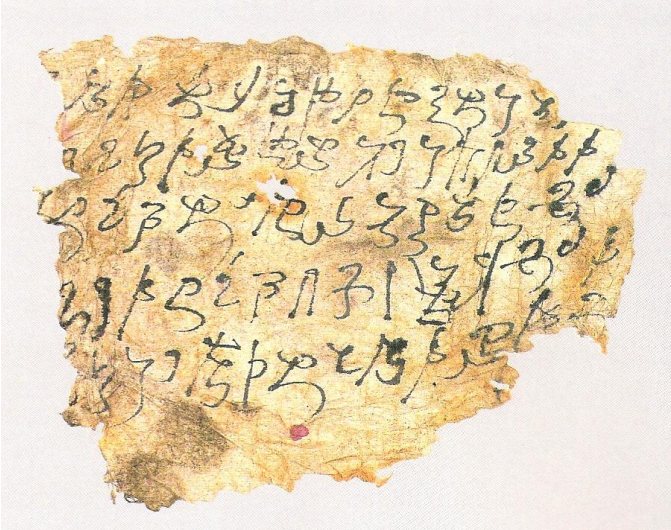

Figure 3: Kharosthi document found in Loulan by Aurel Stein(Wikipedia, 2022)

The application of modern deep learning algorithms to ancient Kalu textual materials enables efficient interpretation. Deep learning is the process of discovering the inherent laws and representation levels of sample data, and the knowledge gained during these processes is extremely useful for interpreting data types such as text, images, and sounds. These include Optical Character Recognition (OCR), Artificial Neural Networks (ANN), and Convolutional Neural Networks (CNN), among others (Fig4). CNN is now the most representative(Assael et al., 2022)[8-11].

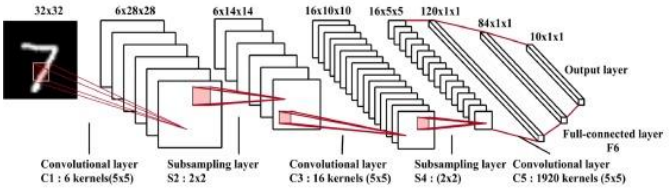

Figure 4: LeNet-5 network(Assael et al., 2022)

CNN is a type of feedforward neural network with a deep structure that includes convolutional computations. It is one of the most representative deep learning algorithms. Convolutional neural networks are capable of representation learning and can classify input data according to its hierarchical structure in a translation-invariant manner(Assael et al., 2022). The use of CNNs enables the identification of visual patterns in archaeological documents, the extraction and learning of features, and the identification of changing patterns that are robust to simple geometric deformations. Convolutional neural networks are composed of at least one convolutional layer, one pooling layer, and one fully connected layer. Additionally, this model can be trained via the backpropagation algorithm. Convolutional neural networks require fewer parameters to consider than other shallow or deep neural networks(Assael et al., 2022).

2.2 Digital Twins Recreate Ancient Ruins

Archaeological relics from Rome, Greece, and Central Asia have been discovered during previous Loulan excavations. The majority of Loulan structures have sloping roofs, but some have flat roofs. The majority of the building's exterior walls are made of wood and bone, with pillars supporting the upper beams and ground burdens, red willow branches interspersed throughout, raw soil attached to the outer and inner walls, and the majority of the roofs are made of reeds and raw soil constitute. Official offices, Buddhist temples, and a few large households have wood walls with rammed earth in the centre. The interior space is relatively compact, with corridors connecting the rooms (Fig5). The walls are extremely thick, and those near the official offices can reach a height of approximately 1.2 metres(Li et al., 2019).

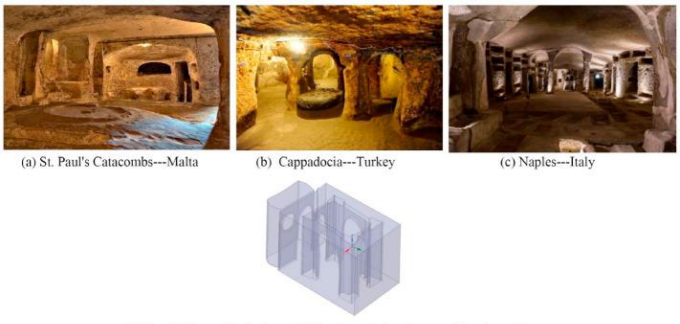

Figure 5: The digital model of characteristic elements (Zhang et al., 2022)

In archaeological work, digital twin technology can be used to inexpensively and intuitively recreate the original scene of relics. A digital twin is a simulation process that integrates multiple disciplines, multiple physics, multiple scales, and multiple probabilities by fully utilising the physical model, sensor updates, operation history, and other data(Trento et al., 2020). It must first perceive, model, analyse, and reason, before finalising the mapping in the virtual space to reflect the entire life cycle of the corresponding physical equipment(Zhang et al., 2022). The digital twin establishes feedback between the real-world physical system and the digital model of cyberspace, assisting in the preliminary digital restoration of ancient ruins in archaeology [12-17].

2.3 IOT Improve Scenic Services

The Internet of Things, or IoT, is a vast network formed by the network's integration of various information sensing devices, enabling the interconnection of people, machines, and things at any time and from any location(Tripathy et al., 2018). In general, IOT connects any item to the Internet via information sensing equipment such as radio frequency identification, infrared sensor, global positioning system, or laser scanner, and conducts information exchange and communication in order to realise the item's realisation, as shown in Figure 6.

Figure 6: The popularization of IoT systems in urban life(Tripathy et al., 2018)

Nowadays, the Internet of Things is being successfully implemented in the tourism industry. For instance, intelligent security systems in scenic locations, passenger flow monitoring, and disaster early warning systems, among other things. Additionally, resort managers can collect data on visitor activity and responses using sensors placed throughout popular tourist destinations in order to structure and guide future scenic development(Verma et al., 2021).

2.4 AR Enhances Sensory Experience

To successfully restore the ancient Loulan Kingdom, it is necessary to consider both the physical and virtual components. AR technology can be used to restore and display cultural relics; that is, on the original site of cultural relics or incomplete cultural relics, the restored portion and the remaining portion of the relics are seamlessly combined via AR technology, allowing visitors to comprehend the relics' original appearance and achieve an immersive effect(Verykokou et al., 2014). It is suitable for recreating cultural sites and classic scenes. AR technology is used to perform real-time positioning and map construction of outdoor structures (such as mythological figures in scenic locations, historical scenes, and so on).

The process of creating a complete augmented reality experience begins with the collection of data from the real world via cameras and sensors and transmission to the processor for analysis and reconstruction, followed by the real-time updating of the user's spatial position change data in the real world via cameras, gyroscopes, sensors, and other accessories, in order to obtain the relative position of the virtual scene and the real world, as well as coordinate system alignment and perceptual alignment(Yung & Khoo-Lattimore, 2019). Users can collect control signals via augmented reality headsets or interactive accessories attached to smart mobile devices, such as microphones, eye trackers, infrared sensors, cameras, and sensors, and perform corresponding human-computer interaction operations(Jingen Liang & Elliot, 2021)[18-19].

3. Proposed Feasibility Arguments

3.1 Successful Application of AI and BIM in Sanxingdui Archaeology

At the Sanxingdui archaeological excavation site, the mobile scanning space detection technology based on SLAM (real-time positioning and mapping) and the COSMOPlat-provided Sanxingdui digital twin cloud platform have taken on the critical tasks of 3D digital scanning, archiving, and modelling. It provides a spatial digital solution for cultural heritage preservation and dissemination, such as smart archaeology and digital museums.

This system is capable of collecting archaeological site data efficiently and accurately, as well as archiving the excavation process in real time. It provides strong support for the development of intelligent archaeology and digital space within the system(YNET, 2021).

The scanned data is then processed by the Sanxingdui digital twin cloud platform to create a real-time interface, reconstruct the three-dimensional scene of the site, and connect it to the temperature and humidity, carbon dioxide, PM2.5, and other data from the excavation site in order to achieve visualisation, management, and availability. Simultaneously, data is collected in the cloud, and an AI algorithm is used to automatically send commands to various IoT devices in the excavation cabin, enabling automatic adjustment of the on-site environment, ensuring that the excavation cabin's environmental parameters are always within a safe range, and preserving the original quality of cultural relics.

The Sanxingdui digital twin cloud platform's main screen is a 1:1 virtual restoration of the Sanxingdui site. Archaeologists can use the large screen to browse and observe every corner of the venue from the first person perspective, as well as master the exhibition hall's layout and style. While monitoring, it can also collaborate with remote experts via audio and video monitoring to provide remote guidance and prevent cultural relics from being lost(YNET, 2021).

3.2 AR Plays an Important Role in Digital Restoration of Notre Dame

Notre Dame de Paris Cathedral is one of Europe's most famous Gothic structures. On the afternoon of April 15, 2019, a fire broke out in Notre Dame de Paris, severely damaging the entire structure, including the spire, which was completely destroyed. For three years, numerous institutions have attempted in various ways to restore Notre Dame(Events, 2020). For instance, take the augmented reality exhibition 'Notre-Dame de Paris: the Augmented Exhibition' hosted by Historyvery (Fielder, 2022).

The exhibition took place concurrently in Paris and Washington. The exhibition recreates the interior of the building and significant historical events that occurred here using cutting-edge technology such as 3D scans and old photographs. Visitors use the Historvery-developed HistoPad touch-screen tablet computer to navigate the exhibition, experience an immersive interactive experience, and travel back in time to the days before the fire at Notre Dame Cathedral(Fielder, 2022). Through the AR scanning map, the AR display tour can trigger AR dynamic effects such as the introduction of scenic spots and the realisation of voice explanations, completing the interaction between the virtual and real worlds (Fig7).

Figure 7: Digital restoration of Notre Dame, on a pad(Fielder, 2022)

The exhibition's timeline spans both the past and present of Notre Dame de Paris. Viewers can witness the construction of the church during the Middle Ages, as well as Napoleon I's coronation (Fig8). The exhibition is visually stunning, with the church floor, historic stained glass, Notre Dame's organ and tolling bells, and a projection of the church's famous rose window. A smorgasbord of audiovisual delights. Additionally, a large model of the cathedral was on display, complete with a full-scale statue. The complex architectural structure and construction techniques of the cathedral can be experienced through a timeline of the cathedral's construction history. Additionally, the exhibition will chronicle the entirety of the fire that destroyed Notre-Dame Cathedral on April 15, 2019, providing an up-close look at how the heroic Paris fire brigade battled for hours to save as much of the structure and its treasures as possible(Fielder, 2022).

Figure 8: Digital reconstructions of historical events, on display(Fielder, 2022)

4. Challenges and Uncertainties

4.1 Trouble in Restoring the Oasis Ecology is the Main Issue

The most difficult aspect of this project is reestablishing the lush environment of water and grass that existed on the desertified Lop Nur over 2,000 years ago. While reversing desertification is a long-term endeavour, it is also an attempt to demarcate an independent land on the desert and establish an autonomous ecosystem within the land, as with the Biosphere 2 project.

Biosphere 2 is a miniature artificial ecological circulation system located north of Tucson, Arizona, in the United States of America. It is 12,000 square metres in size and was constructed in the 1990s. Biosphere 2 is comprised of five natural biomes (rainforest, savannah, ocean, swamp, and desert) and two man-made biomes (intensive agriculture and settlement). They use the ecosystem between the Tropics of Cancer as a model. The circle contains approximately 4,000

species, including approximately 3,000 types of animals and plants and approximately 1,000 types of microorganisms(Cohen & Tilman, 1996). However, during the 1991–1993 experiments, the researchers discovered that because the atmospheric composition of oxygen and carbon dioxide in Biosphere 2 could not reach equilibrium on its own and lacked sufficient decomposers, the majority of animals and plants were unable to grow or reproduce normally, eventually becoming extinct. quicker than anticipated. Following extensive discussion, it was determined that the "Biosphere 2" experiment was a failure and did not accomplish the original designer's objective(Allen & Nelson, 1999).

Although no successful case of establishing an independent ecosystem in a desert exists, there is still hope for scientific and gradual control of desertification, as demonstrated by the improvement of China's Babu Sand Desert.

The Babu Sand Desert is located in China's Hexi Corridor, on the eastern edge of the Tengger Desert. Prior to the control of desertification, wind and sand moved southward at a rate of 7.5 metres per year. Wind and sand raged, forcing people to flee. Over 20,000 mu of fertile land, the production and livelihood of over 30,000 indigenous people, as well as transit roads and railways, have all been harmed significantly. After 40 years of ecological management, a windbreak and sand-fixation forest system comprised of arbour, shrubs, and grasses has gradually developed along the desert frontier of the Babu Sand Forest Farm. Forest and grass vegetation cover in the area has increased from less than 3% prior to treatment to more than 60% now, forming a wind-proof and sand-fixing green corridor measuring 10 kilometres north to south and 8 kilometres east to west(Paper, 2021).

4.2 Tourism Industry Risks Should Not be Underestimated

Along with the challenge of improving the ecological environment, the project must also address the issue of achieving the anticipated benefits. As with many other tourism projects, if the peak season is successful, a large number of tourists will come for sightseeing, but there will always be a low season, and it is difficult to predict whether the income will be stable. Additionally, tourism will face unforeseen crises such as natural disasters and financial crises. For instance, the scenic spot Hengdian Film and Television City, which operated smoothly in the early stages, sustained losses following the outbreak of the new crown disease at the end of 2019.

Hengdian Film and Television City Scenic Spot is a large-scale integrated tourist area in Zhejiang Province, China. It combines film and television, tourism, and vacation. Over 30 scenic areas spanning time and space and incorporating regional characteristics have been constructed, including the Ming and Qing Palace Gardens, the Qingming Riverside Map, and the China Revolutionary War Expo City. Hengdian Film and Television City is not only a film and television production location, but also a popular scenic tourist destination in China. Hengdian Film and Television City, on the other hand, has suffered significant losses in recent years as a result of the new crown epidemic. According to Hengdian Film and Television's 2020 annual report, the company's operating income was 990 million yuan in 2020, a decrease of 66.27 percent year on year. The non-net profit loss was 468 million yuan, increasing the loss range by 307.8%(Media, 2021).

However, cutting-edge technology and the Internet can help mitigate the revenue loss caused by the epidemic and the harm caused by scenic spots being forgotten in the event of an unexpected crisis. For example, Dunhuang launched the "Dunhuang Travel" project during the epidemic period, allowing visitors to browse Dunhuang from their homes, in addition to the live scene and augmented reality protection of cultural relics, ensuring that Dunhuang's popularity has never waned[20-22].

As a result of the new crown pneumonia epidemic, the Dunhuang Research Institute has suspended the Mogao Grottoes and other grottoes under its jurisdiction since January 24. "Dunhuang Travel" will be launched at the end of February 2020, with videos, art forms, dynasties, colours, and panoramic caves. Due to the new crown pneumonia, visitors are unable to visit the museum and experience it firsthand. Digital technology enables people to "tour" a variety of museums and interact with a variety of cultural relics. The tour and protection component of the mini-program not only educates tourists about the history and culture of Dunhuang before they enter the scenic spot, but also provides necessary guidance for tourists on how to participate in the field experience's protection of Dunhuang(Daily, 2020). When tourists enter the digital Dunhuang, they can rotate and zoom in on the details of the scenic spots in the panoramic grottoes, which not only saves time for crowded tourists, but also allows for a more in-depth dialogue with the cave artists thousands of years ago.

5. Conclusion

Because of the rapid development urban sensing and computing, the combination of smart archaeology and tourism is still a relatively new industry in today's society. Using the ruins of the ancient country of Loulan as an example, this paper explores the possibility of incorporating urban informatics technology and methods into the archaeology and tourism of the ruined ancient country of Loulan. Loulan was an ancient dynasty, northwest China, with a history that dates back more than 2,000 years. It is believed to have perished as a result of climate change.

Following that, this paper proposes the use of deep learning algorithms to interpret ancient documents, the use of digital twin platforms to recreate ancient ruins, the use of intelligent Internet of Things systems to enhance scenic services, and the use of augmented reality technology to display diverse travel experiences, all of which are discussed in greater detail below. The reliability of the various techniques described in this paper has been established through preliminary application in the archaeological work at Sanxingdui and the digital reconstruction of Notre Dame de Paris.

In addition, the paper discusses some of the current challenges that this scheme is facing, such as the difficulty in restoring the ecological environment of the desert oasis and the random risks that tourism will be exposed to in the near future. It is possible to apply the technologies and methods proposed in this paper to other archaeological and tourism industries in addition to those mentioned in this paper. With no doubt, the most recent developments in urban informatics technology will have a significant impact on traditional industries.

References

[1] Allen, J., & Nelson, M. (1999). Overview and design biospherics and biosphere 2, mission one (1991–1993). Ecological Engineering, 13(1-4), 15-29.

[2] Assael, Y., Sommerschield, T., Shillingford, B., Bordbar, M., Pavlopoulos, J., Chatzipanagiotou, M., Androutsopoulos, I., Prag, J., & de Freitas, N. (2022). Restoring and attributing ancient texts using deep neural networks. Nature, 603(7900), 280-283. https://doi.org/10.1038/s41586-022-04448-z Association

[3] Z. C. D. (2021). Cultural Tourism IP: Half Art, Half Market. https://baijiahao. baidu.com/s? id= 1708934599136665643&wfr=spider&for=pcCohen

[4] J. E., & Tilman, D. (1996). Biosphere 2 and Biodiversity--The Lessons So Far. Science, 274(5290), 1150-1151.

[5] Daily, B. B. (2021). New exploration of entertainment function, Sanya X "Peace Elite" realizes diversified cultural and tourism value. https://baijiahao.baidu.com/s?id=1698730845365532317&wfr=spider&for=pc

[6] Daily, C. (2020). The users of the "Yunyou Dunhuang" applet exceeded 1 million in ten days, and the post-80s and post-90s accounted for more than 60%. https://baijiahao.baidu.com/s? id=1660311794986420957 &wfr= spider& for=pcEvents

[7] H. i. (2020). Discover Paris in augmented reality! https://blog.pariscityvision.com/discover-paris-in-augmented-

reality.html
[8] Fielder, J. (2022). Notre Dame fire anniversary: How augmented reality brings 1000 years of the cathedral to life. https://www.euronews.com/culture/2022/04/09/notre-dame-fire-anniversary-how-augmented-reality-brings-1000-years- of- the-cathedral-to-li
[9] Jingen Liang, L., & Elliot, S. (2021). A systematic review of augmented reality tourism research: What is now and what is next? Tourism and Hospitality Research, 21(1), 15-30.
[10] Li, K., Qin, X., Zhang, L., Wang, S., Xu, B., Mu, G., Wu, Y., Tian, X., Wei, D., & Gu, Z. (2019). Oasis landscape of the ancient Loulan on the west bank of Lake Lop Nur, Northwest China, inferred from vegetation utilization for architecture. The Holocene, 29(6), 1030-1044.
[11] Media, T. (2021). How far can Hengdian Film and Television's "Chinese Hollywood" dream go? https://baijiahao.baidu.com/s?id=1715550528306123091&wfr=spider&for=pc
[12] Mischke, S., Liu, C., Zhang, J., Zhang, C., Zhang, H., Jiao, P., & Plessen, B. (2017). The world's earliest Aral-Sea type disaster: the decline of the Loulan Kingdom in the Tarim Basin. Scientific Reports, 7(1), 1-8.
[13] Paper, T. (2021). Typical Cases of Ecological Restoration in China (14)/Desertification Control in Gulang Babu Sand Forest Farm. https://m.thepaper.cn/baijiahao_14989497
[14] Sun Yaqin, X. J. (2021). Analysis of the reasons for the success of cultural and creative products of the Forbidden City. https://m.fx361.com/news/2021/0128/7675391.html
[15] Trento, A., Kieferle, J. B., & Wössner, U. (2020). A Decision Making Tool for Supporting Strategies of Archaeological Restoration-Case Study of Ostia, Maritime'Portus' of the Imperial Rome.
[16] Tripathy, A. K., Tripathy, P. K., Ray, N. K., & Mohanty, S. P. (2018). iTour: The future of smart tourism: An IoT framework for the independent mobility of tourists in smart cities. IEEE consumer electronics magazine, 7(3), 32-37.
[17] Verma, A., Shukla, V. K., & Sharma, R. (2021). Convergence of IOT in Tourism Industry: A Pragmatic Analysis. Journal of Physics: Conference Series
[18] Verykokou, S., Ioannidis, C., & Kontogianni, G. (2014). 3D visualization via augmented reality: The case of the middle stoa in the ancient agora of athens. Euro-Mediterranean Conference
[19] Wikipedia. (2022). Loulan Kingdom. https://en.wikipedia.org/w/index.php? title=Loulan_Kingdom&oldid= 1073465873
[20] YNET. (2021). These black technologies "escort" the latest unearthed cultural relics in Sanxingdui. https://t.ynet. cn/baijia/31447297.html
[21] Yung, R., & Khoo-Lattimore, C. (2019). New realities: a systematic literature review on virtual reality and augmented reality in tourism research. Current issues in tourism, 22(17), 2056-2081.
[22] Zhang, J., Kwok, H. H., Luo, H., Tong, J. C., & Cheng, J. C. (2022). Automatic relative humidity optimization in underground heritage sites through ventilation system based on digital twins. Building and Environment, 108999.