ICIC Express Letters
Part B: Applications
Volume **8**, Number **12**, December **2017**
 ISSN 2185-2766
pp. 1577–1583

LOCATION-BASED AUGMENTED REALITY FOR EXPLORATION OF CULTURAL HERITAGE

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Received June 2017; accepted September 2017

Abstract. *This study proposes the use of a crowdsourcing strategy to preserve cultural history and educate people in it through universal participation. To satisfy user motivations for crowdsourcing, based on gamified crowdsourcing for cultural heritage (GCCH) and location-based augmented reality technology, a gamified navigation system for cultural heritage exploration called "Explore Memory in Reality" is developed in this study. With a historically and culturally important park as test venue, the effect of the participation of subjects was analyzed qualitatively and quantitatively using the proposed system. The results showed that gamified crowdsourcing can positively influence the sustainable development of cultural heritage and improve public self-assessment pertaining to awareness of local history and culture. It also has significant potential for use in the tourism industry in the future.*
Keywords: Gamification, Location-based service, Augmented reality, Crowdsourcing, Cultural heritage

1. **Introduction.** The preservation and maintenance of cultural heritage is considered important worldwide. Humans and natural disasters have damaged numerous historical monuments and sites of great importance, and a large number of unique folk arts are in danger of cultural extinction due to the lack of qualified practitioners. In recent years, digital archiving has been widely used to preserve and present cultural heritage. However, this technology poses certain challenges with its software/hardware maintenance and update costs. Common problems associated with traditional digital archiving include a) manpower, resources, capital, and time limitations; b) the rate of cultural knowledge preservation is slower than the rate of damage and disappearance occurring; and c) the lack of public participation in preserving cultural heritage and assuming social responsibility for it. Although protecting cultural heritage is the official duty of the authorities, cooperation and participation of the public are indispensable. In light of the limitations posed by traditional digital archiving, and the needs to preserve cultural heritage more effectively, this study used modern mobile devices as carrier, and utilized gamified crowdsourcing for cultural heritage (GCCH) method and location-based augmented reality (AR) technology to develop a gamified navigation system for the exploration of cultural heritage. This system renders a city as a massive museum as well as an amusement park, where the boundary between the virtual world and reality is vague. The game aims to improve people's cultural identity. If gamification can successfully promote tourism around historical monuments, it will contribute towards heritage preservation and sustainability. Moreover, if the game design properly takes advantage of GCCH and guides the users in recording photos, videos, and even texts pertaining to historical monuments at different times in the future, long-term accumulated data can become a substantial source for

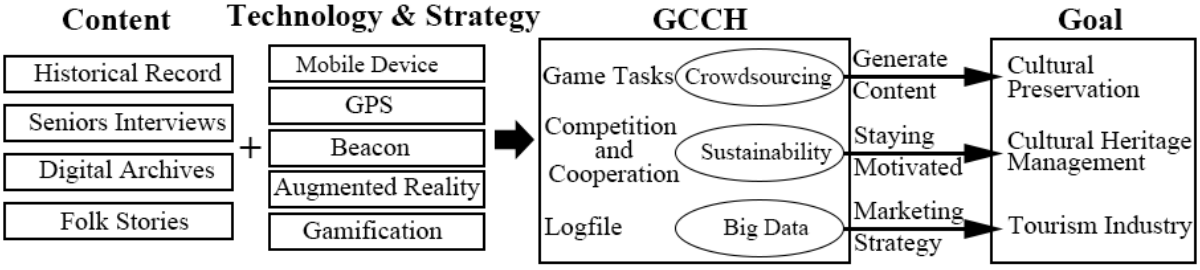


FIGURE 1. Gamified crowdsourcing for cultural heritage

cultural research as well as content development materials for the gaming system. The concept of GCCH is illustrated in Figure 1.

The objectives of this study are to: 1) implement crowdsourcing through gamification, and realize culture learning through universal participation; 2) examine how to motivate participants to consistently pay attention to and participate in the given plan; and 3) investigate whether location-based AR gaming can add value to cultural content. The achievement of these objectives will in turn help design better content using gamified crowdsourcing and AR, increase user participation and their cultural identity, promote the local tourism industry and eventually, achieve cultural sustainable management.

This paper will begin by providing the background and explanation on key concepts through the review of past literature and specific examples. Subsequent sections will detail the process of designing the game system and test, and finally, the paper will present results from the test and draw relevant conclusions.

2. Literature Review.

2.1. Crowdsourcing.

Crowdsourcing refers to the outsourcing of work requiring massive manpower to an indefinite group of volunteers through a certain platform. This type of content usually involves trivial work executed by a large number of people and unlikely to be completed by computers [1]. An example is Wikipedia, an encyclopedia created using the power of crowdsourcing, and is now one of the most visited websites [2]. Crowdsourcing has been used in the domain of cultural heritage for a variety of tasks [3]. With the popularization of mobile devices and networks, cultural heritage preservation is possible with crowdsourcing if mobile devices are adopted as a collaborative platform. By eliciting the public's sense of local cultural identity, they will collaborate in the consistent renewal of content.

2.2. Gamification.

Gamification was first proposed by programmer Nick Pelling in 2002 [4] but not extensively used until 2010. It is the strategy of using gaming elements in non-game contexts [5]. According to a 2014 survey on over 2,000 multinationals[1], at least 70% had used gamified apps to market or maintain customer relations. By 2015, half the enterprises featuring innovation had incorporated gamified elements in their workflow. Growing research on gamification is focusing on how it changes people's behaviors. The application of gamification is evident in nearly every aspect of daily life; however, seldom seen in cultural preservation and sustainable management. Therefore, we aim to use GCCH to increase the public's sense of local cultural identity and awareness of their cultural assets. This application has the potential to boost local economies by increasing tourism, and realize sustainable management.

[1]The research was conducted by Gartner Inc., a US research advisory company.

2.3. **Influence of location-based AR gaming on the real world.** AR technology is a rapidly developing field in computer science with several commercial applications, including in museums [6]. Some apps related to cultural heritage have been developed using AR technology [7] and location-based games have lately emerged. The idea is to move the venue from PCs to cities, streets, or any other places in the "real world" [8]. This type of game typically uses AR to integrate the virtual and real gaming mechanisms to enhance the level of interactive education and recreation [9]. Ingress, released by Google in 2012, is a good example [10]. Users have found the game engaging, and have actively participated. Google has collected and analyzed data on gamer behaviors through large-scale multi-national activities around the world. In May 2016, Google chose Tainan, a history- and culture-rich city in Taiwan, as one of the locations for Mission Day [11]. It incorporated local historical sites in game task planning to help users better understand the cultural characteristics of this centuries-old city. This also generated considerable profit from tourism for Tainan.

Nintendo, in collaboration with the Ingress development team, Niantic Lab, released the famous location-based AR game Pokémon GO in 2016. In this game, users have to go to various locations in the real world to catch different Pokémon [12]. This gaming mechanism has led to a series of unprecedented social phenomena around the globe. To accomplish the game's tasks, many people who had previously stayed at home have taken to being outdoor all day. It has also caused massive public gatherings such as the one in Beitou District of Taipei [13]. The Pokémon GO phenomenon also highlights the importance of meaningful links between technology, gaming content, and culture [14]. Such mechanism coincides with the gamification application developed in this study.

3. Research Method.

3.1. **System development.** A location-based AR game called Explore Memory in Reality is developed in this project and the 228 Peace Memorial Park in Taipei was selected as test venue. With a rich cultural background covering various dynasties and historical periods, this park epitomizes the history of Taiwan. Game tasks were configured at 10 locations in the park, each with its own historical story. For instance, the New Park Stadium, built during the Japanese occupation, was converted into a Chinese-style garden (left, Figure 2). The Great Queen of Heaven Temple of the Qing Dynasty no longer exists, and the original site now only has a stone tablet (right, Figure 2). The inscriptions on these tablets are seldom read by people, and we integrated them into our game content.

FIGURE 2. The site in the past and the present. Left: the New Park Stadium (Birns, 1949) [15]. Right: the Great Queen of Heaven Temple (Ishikawa Genichiro, 1899) [16].

Explore Memory in Reality features a creature only the user can see through the mobile device. This creature needs to collect fragments of memory to return to its own world, and asks the user for help. It provides clues for the user to solve mysteries in the real world. The tasks are based on the history of the area. To properly integrate the game scene with reality, GPS is used in combination with the Bluetooth positioning system Beacon to enhance positioning accuracy. When the virtual character is triggered, data from a gyroscope is used to calculate its position relative to the cellphone. The image

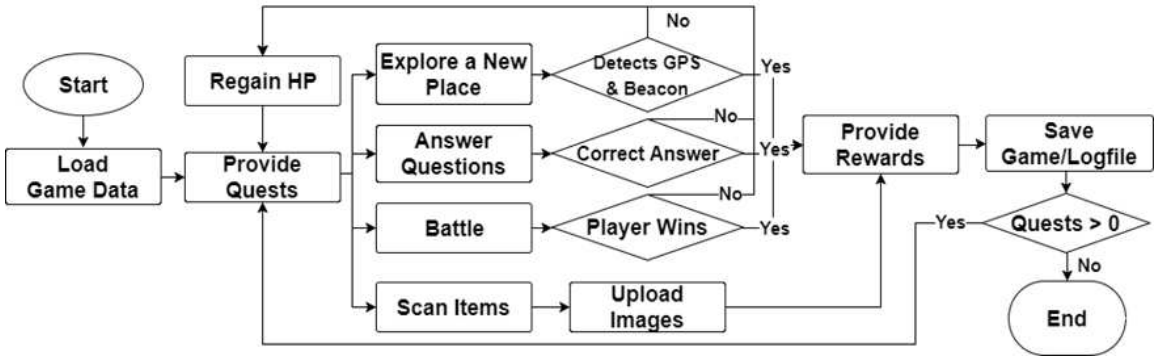


FIGURE 3. Flowchart of the developed system

captured by the cellphone camera is the scene background, where the virtual character appears through AR. Many tasks ask the user to find a certain tablet, site, or statue to scan, or to take a snapshot. The system then uploads, sorts, and saves these images in a database that serves as initial validation for crowdsourcing. User behavior during gaming is saved in log files used in the post-test data analysis. A flowchart of the game system is shown in Figure 3.

The user is asked to create an ID at system start. The saved records can be loaded at subsequent logins. User data during gaming is recorded, including the number of completed tasks, time spent, the number of mistakes made in unlocking mysteries, fighting scores, and so on, constituting important data for behavior analysis. Enemies appear in the game, surround the user in the AR setting and try to attack. The user can click the screen to fight back. Answers to some riddles are hidden in the inscription on the tablets in real world. Therefore, users have to hunt for the correct tablets and answers. Pictures of the gaming system are shown in Figure 4.

FIGURE 4. Photos of the gaming system

In the game, being attacked while fighting and mistakenly answering riddles lead to loss of energy. If the energy reduces to zero, the user is temporarily disabled in the game. However, energy is gradually recovered, and rewards obtained in the game yield energy boosts, thus encourages users to become involved.

3.2. **Test design.** A total of 56 subjects participated, with an age range of 18-36 years and a male-female ratio of 48.2%-51.8%. The test was conducted over two days, during which the subjects went to the test venue at times convenient for them. The app was made available in Google Play to download and install. For subjects whose cellphones did not have the gyroscope function, we provided backup mobile devices on site.

In addition to basic information as gender and age, a questionnaire asked users about their usual gaming times, and whether they had played other location-based AR games

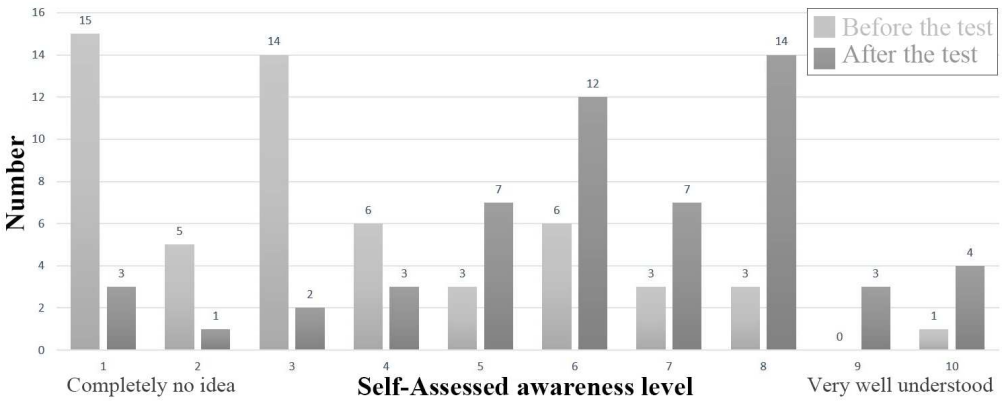
such as Ingress or Pokémon GO. These questions helped determine whether subjects with rich general gaming experience or similar game experiences familiarized with our game more quickly. Moreover, a self-assessment form gauged users' familiarity with the historical/cultural background of the park before and after the test. The evaluation scores ranged from "completely no idea" (1) to "extremely familiar," (10), and intended to measure the users' perceived improvement in their knowledge through the game. The system usability scale (SUS), game flow, and the ARCS (attention, relevance, confidence, and satisfaction) were incorporated into the questionnaire to provide quantitative data; this was accompanied by qualitative interviews. The behavioral data were saved in log files, including time spent exploring each target, number of mistakes made when unlocking mysteries, GPS route to the target, fighting scores, and damage incurred while fighting. The quantitative questionnaire consisted of 55 questions on a five-point Likert-type scale. Cronbach's α (reliability measure) was determined to be 0.934, greater than 0.8, hence verifying the reliability of the questionnaire. Example questions from the qualitative interviews include: "What is the most appealing part of the game?" and "What element or content would you if you were asked to design or modify the game?" During the test, we observed 30% naturally formed teams when attempting to unlock mysteries. Many subjects did not know one another before and were brought together by the game. Non-subjects on site asked about our activity and many expressed desire to participate. Figure 5 shows photos taken during the test.

FIGURE 5. Some photos taken during the test

4. **Results.** Table 1 shows the distribution of users' self-assessed awareness level of the historical/cultural background of the park before and after the test. More than half the users hence improved from "completely no idea" (1) to the intermediate level (4-5). The prior- and post-game assessment comparisons can be seen in Table 1.

For SUS Score, Cronbach's $\alpha = 0.801$ was indicative of acceptable reliability. In all data, gender did not show a significant influence on usability. The total SUS average was 79.73214286, between B (excellent) and C (good). This suggests the system was easy to use for subjects but there is room for improvement to reach the highest level, A.

TABLE 1. Self-assessment of awareness before and after test



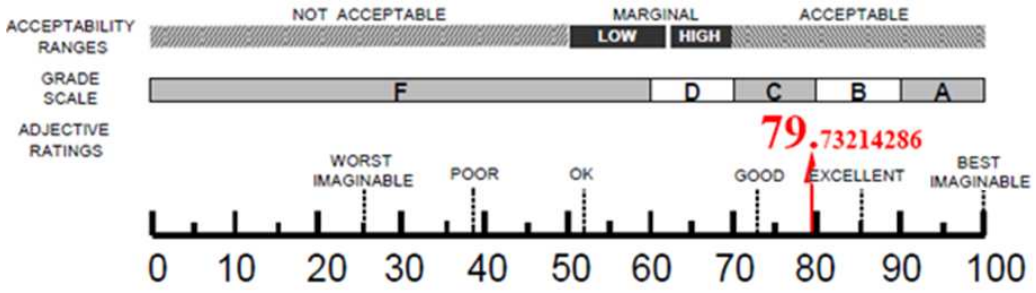


FIGURE 6. SUS score

For game flow, Cronbach's $\alpha = 0.925 > 0.85$, indicating fairly high reliability. A t-test using gender as independent sample showed that it did not generate significant differences in game experience flow.

For ARCS, Cronbach's $\alpha = 0.938 > 0.85$, suggesting fairly strong reliability. The results showed that gender was not significant, meaning the gamified design offers men and women similar gaming experience.

In qualitative interviews, approximately 30% of users thought there was too much text in the game, and suggested using more videos or images in the future. Most subjects said the most appealing part of the game was unlocking the mysteries because they needed to carefully read the inscription on the tablets. They reported a sense of achievement with the unintended and surprising benefit of gaining historical knowledge. This was apparently very important for the subjects. When responding to the question *"What element or content would you add if you were asked to design or modify the game?"* many users mentioned in-game items/skills, more hints, the social media and improvements in the visuals and the interaction. When asked *"Would like to have marketing exposure in this game if you owned a business near the 228 Peace Memorial Park?"* 90% of the subjects were willing. Many suggested the possibility of collaborating with nearby beverage stores, as considerable amount of walking is involved, and gamers get thirsty, making beverage stores the perfect business partners.

The log files showed most people spent more time on tasks involving places with poor Beacon reception or long-distance targets with limited hints. Subjects with experience in location-based games "warmed up" relatively quickly, as suggested by their speed of exploration in the first and second tasks. However, no significant difference was observed from the third task onward. The subjects found finding targets in a long distance challenging, even with hints, primarily because adopting a systematic route is hard unless you are very familiar with the park. For future design, it is important to guide users so it is easier for them to recognize the area while avoiding excessive hints that make the game unchallenging. The log files also suggested it would substantially help if the venues of consecutive tasks were within sight of each other. In terms of image uploading, most subjects captured the expected images, suggesting the desired crowdsourcing effect can be achieved through proper game guidance. The few failed task cases were, according to our analysis, due to network reception problems.

5. **Conclusions.** The test results showed that the proposed game method can remarkably improve subjects' awareness of local culture and history, providing similar experience for male and female users. However, some problems were identified, for example, to avoid user experience being negatively affected due to network issues and delay in image upload, a task was deemed completed as soon as an image was correctly taken by the user. We found that image upload failures occurred more often at locations with poor mobile data reception. Hence, finding a trade-off between satisfying crowdsourcing requirements and user experience is a critical task for future work, but our experiment preliminarily proved

the feasibility and value of GCCH. The integration of the unlocking of mysteries in the game into historical monuments was well received of by all subjects.

In summary, this study has proven that 1) crowdsourcing through gamification is feasible; 2) gamification can effectively motivate participants to learn about local culture; and finally 3) location-based AR gaming can add value to cultural content. These findings take us another step further towards the long-term goals of greater local cultural identity, and cultural sustainable management.

In the future, multi-player and community interactive elements will be added to the game, with the aims of triggering stronger user motivation and strengthening the function of crowdsourcing. With more comprehensive functionality based on further testing and development, the game will be made available on Google Play and the iOS App Store for crowdsourcing at a larger scale.

Acknowledgment. This research was partially supported by the Ministry of Science and Technology, Taiwan, under Grant No. MOST 104-2221-E-027-075.

REFERENCES

[1] J. Howe, The rise of crowdsourcing, *Wired*, vol.14, no.6, pp.1-4, 2006.
[2] C. Shirky, *Here Comes Everybody: The Power of Organizing without Organizations*, Penguin, 2008.
[3] D. Paraschakis, *Crowdsourcing Cultural Heritage Metadata Through Social Media Gaming*, Master Thesis, School of Technology, Department of Computer Science, Malmö University, 2013.
[4] A. Marczewski, *Gamification: A Simple Introduction and a Bit More*, Self-published on Amazon Digital Services, Kindle Edition, 2013.
[5] K. Werbach and D. Hunter, *For the Win: How Game Thinking can Revolutionize Your Business*, Wharton Digital Press, 2012.
[6] R. Hammady, M. Ma and N. Temple, Augmented reality and gamification in heritage museums, *Joint International Conference on Serious Games*, pp.181-187, 2016.
[7] J. Shin, J. Kim and W. Woo, Narrative design for rediscovering Daereungwon: A location-based augmented reality game, *IEEE International Conference on Consumer Electronics (ICCE)*, pp.384-387, 2017.
[8] C. Neustaedter, A. Tang and T. K. Judge, Creating scalable location-based games: Lessons from geocaching, *Personal and Ubiquitous Computing*, vol.17, no.2, pp.335-349, 2013.
[9] J. Weber, *Designing Engaging Experiences with Location-Based Augmented Reality Games for Urban Tourism Environments*, Ph.D. Thesis, Bournemouth University, 2017.
[10] N. Hulsey and J. Reeves, The gift that keeps on giving: Google, Ingress, and the gift of surveillance, *Surveillance & Society*, vol.12, no.3, p.389, 2014.
[11] *Mission Day Tainan*, http://events.ingress.com/MissionDay/Tainan, 2016.
[12] L. J. Dorward, J. C. Mittermeier, C. Sandbrook and F. Spooner, Pokémon GO: Benefits, costs, and lessons for the conservation movement, *Conservation Letters*, vol.10, no.1, pp.160-165, 2017.
[13] J. Nash, *Pokémon GO May Have Just Shown us What the End of the World Looks Like*, http://time.com/4460911/pokemon-go-taipei-stampede-snorlax-mob-xinbeitou-taiwan/, 2016.
[14] F. Mäyrä, Pokémon GO: Entering the ludic society, *Mobile Media & Communication*, 2016.
[15] J. Birns, *Football in Taipei Park*, https://www.thenewslens.com/article/13379, 1949.
[16] I. Genichiro, *Photo Album of Famous Sights in Taiwan, 1899*, http://www.tonyhuang39.com/tony1094/tony1094.html, 2016.