PhotoStory: Mobile Application for Preserving Historical Heritage Using Timeline View

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Abstract—This paper proposes a PhotoStory: a mobile-based application to record the transformation of buildings, including the condition of the buildings and the surrounding environment, whether caused by natural disasters or other factors. There are still limited systems available for people to see the changes in historical buildings. Some existing applications only focus on collecting photos, but the images are not timeline-organized. This research aims to design a mobile application system that can separately group the building photos sent by users through a geotagging-based mobile application and then visualize it on a timeline-view layout. Grouped photos will make it easier for users to see and trace the context of the building. The respondents then try the Photostory application and are asked for their opinion regarding their use. Based on the usability tests that have been done, the system obtained a value of 87,27%, with the Efficiency parameter getting the highest deal among other usability parameters, which was 94%. The obtain shows that the system has been designed successfully. As a result, users feel satisfied and become more familiar with historical buildings. Furthermore, using a timeline-view layout proves that it can provide good effectiveness to users in understanding the transformation of buildings.

Keywords—photo buildings, historical heritage, geotagging, timeline-view

1 Introduction

The digital documentation process of a historical site becomes critical to avoid historical heritage information loss. Indonesia has many ancient buildings and ancient sites with high historical value. It may provide the country's young generation with an overview and information on the site's existence and background. The United Nations Educational, Scientific and Cultural Organizations (UNESCO) have noted more than a thousand world heritage sites [1].

The community's enthusiasm to be involved in the digital documentation of the historical object via social media is relatively high. The respondents said they were excited to participate in the project [2]. Moreover, when tourists visit an ancient building, they usually take pictures and share them on social media. No wonder there are

1713 pictures in Architecture, Building, and Construction categories shared by 145 users on the photo-sharing site Flickr.com [3].

Currently, there is no system that the general public can use to record and see the historic buildings and their surrounding environment changes over time. The recording is helpful to make it easier for the community and related parties to view information and monitor the condition of the place. There are some applications related to cultural heritage; Europeana [4], Cultural Gate [5], and The Prow [6]. But those applications only focus on collecting photo data and are displayed unorderly. Hence, it is difficult to see the changes in the building conditions.

Some previous systems are no longer accessible, making them difficult to use as a reference for this research. In addition, there are still no applications utilizing crowdsources that focus on preserving historic buildings.

The successive stages of this research are literature study, system analysis, the process of formulating system requirements, system development, testing and deploying, taking results, and discussion.

This research focuses on developing a mobile application that can accommodate people's habits in photographing ancient building objects and sharing pictures.

Although several applications have used crowdsourcing, for example, the e-complaint system proposed by Basid [7], they have yet to specialize in historic preservation. It is hoped that the system developed will also be a reference for other researchers conducting similar research (which involves crowdsourcing). This application will help observers of historic buildings in the documentation (preservation) of historic buildings. In addition, general users can help by taking & sharing photographs. And for the government, it is hoped that it can assist in making policies related to historic buildings.

2 Literature review

Some researchers have used various approaches to visualize the ancient building as a historical object. For example, the research about the design of a tour guide application service motivates tourists to receive cultural heritage travel information. The application used the User-Centered Design (UCD) method that focused on the user in every phase of the design process [8].

Some photo documentation can be a source of information that can provide knowledge to the community about the history, development, and changes that occur in the building. By utilizing the capabilities of mobile devices, we can add information to an image file by adding metadata or an Exchangeable Image File (EXIF) [9] so that the information can be utilized in the future.

Stefani et al. [10] have researched the development of systems that provide access to information about historical sites. This research focuses on making 3D models based on photos of historical buildings that have been there before. Their system collects photos taken by visitors and stores them in the database. Furthermore, the images are compiled and taped into 3D models. Each image is given a semantic description. So when the user selects an image, the system will display the visual image in 3D, and the user can interact with the 3D model to view information according to the object. Liestøl [10] used augmented reality (AR) to visualize the historical place and combined it with narrative storytelling to explain the information about the site.

A method proposed by [11] focused on a system for storing various kinds of images in a platform named Locus Imaginis that provides information about certain monuments. This online platform allows visitors to broaden their trip through photos taken and expand them with data from the platform's database.

Research by [12] discussed classifying of historic building sites using transfer learning. This research focused on image classification and query-based retrieval of image labels.

Table 1 summarizes some of the applications related to historical heritage. All apps in Table 1 are accessible freely, so the public can easily access the app. Moreover, all applications also provide features for users to send files to the server. However, only The Prow does not support a mobile application. Our proposed application offers a timeline-view layout, while other applications use maps and list for data visualization. We also apply the concept of grouping content based on place and time.

Table 1. Comparison between other heritage platforms

Platform	Public View	The ability of any user to upload data	Platform Scope	Mobile Application	Data Visualisation Model	Grouping of content
Proposed Application	Yes	Yes	International	Yes	Map, List, Timeline	Yes
Europeana [4]	Yes	Yes	International	Yes	List	No
Culture Gate [5]	Yes	Yes	International	Yes	Map, List	No
MQUADRO [13]	Yes	Yes	Local	Yes	List	No
The Prow [6]	Yes	Yes	Local	No	Article	No

Based on the other four applications in Table 1, the application of the culture gate is the most recent. So we will compare our proposed application with the culture gate application using the usability test method.

From a review of the existing literature, this research establishes several research questions; can the developed mobile application accommodate user needs in capturing photos and sharing them on social media? Can the built system provide a website to display maps related to historic buildings? Can the website display pictures of historic buildings based on a timeline?

This developed system can help stakeholders (observers of historic buildings, application users, and government preserve historic buildings.

3 Methodology

3.1 Literature review

Literature data collection was carried out by searching reputable journals using keywords such as historical building, historic building preservation, historical preservation, timeline view application, and crowdsourcing. Apart from that, literature data collection was also carried out by conducting interviews with experts in the fields of historical heritage and historical architecture.

3.2 Instruments data gathering

Before developing the system, the researcher first collected historical building information in the form of photos and documents from several sources, both from social media and individual blogs and by visiting several historical buildings directly.

To find out the completed system development results, the researcher distributes the application link to users/respondents via social media and email.

3.3 System/Application testing result gathering

There are two kinds of application/system testing result data: application result data and usability testing results.

System/Application data. Application data comes from internal sources and users. Internal sources are obtained from collecting photo data of buildings spread on the internet, such as on social media. The source of application data that comes from users is photo data of buildings obtained by taking photos of historical buildings directly. Table 2 shows the data of one particular building in the system database.

Table 2. Data of building in the system database

No	Name	Latitude	Longitude	Address	Photograph Direction	Year	Image
1	Masjid Jami Malang	-7.982376	112.629937	Kota Malang	West (W)	1910	
2	Masjid Agung Jami Kota Malang	-7.982665	112.630807	Kota Malang	West (W)	2010	
3	Masjid Jami' Malang	-7.982462	112.632416	Kota Malang	West (W)	2022	

Usability testing. Usability testing is one of the essential activities in software development to determine user satisfaction with the software [14].

The questionnaire will be given to the respondents. Usability testing is carried out to determine the usability level of the system.

Several categories in usability testing are learnability, efficiency, memorability, errors, and satisfaction. Usability testing is done by making instrument questions that are given to respondents. Responses/answers using a Likert scale with a score of 1-5 (1: strongly disagree and 5: strongly agree). The list of questions used in the questionnaire is shown in Table 3.

Table 3. List of questionaire

No	Question	Category
1	I think it is easy to figure out the menu in this application.	Learnability
2	I think this application is easy to learn	
3	I think this application helps me to see the visualization of the building's transformation from time to time	Efficiency
4	I think this application has features that are easy to use.	
5	I think the features of this app are easy to remember	Memorability
6	In my opinion, the features of this application are easy. In my opinion, it is not easy to forget how to use this application easily	
7	I think that I did not make many mistakes when running this application.	Errors
8	In my opinion, if I make a mistake in using this application, it will be easy to correct the mistake	
9	I find it very convenient to use this application	Satisfaction
10	I think the design of this application is satisfactory	
11	I think overall this application is satisfactory	

The respondents who participated in this study were ten people. The age range of the respondents ranged from 18-30 years. We determine the characteristics of respondents who are active on social media and like traveling, especially to historical areas.

4 Result

The system's design involves the community sharing photographs of the ancient building they had taken. PhotoStory's mobile application will use the metadata in the image file. This system consists of two sides; the client side and the server side. Figure 1 shows the architecture of the proposed method.

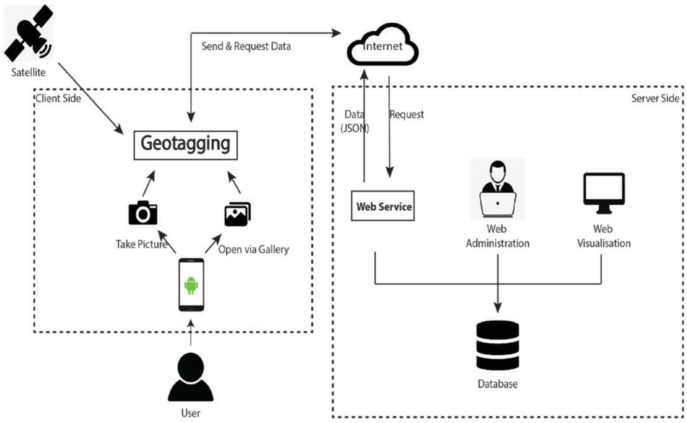


Fig. 1. The architecture of the system

PhotoStory is a mobile-based application on the client side. It can be accessed by users to take photos of the ancient building. Some models are involved in the system. The following part will describe the models.

4.1 Role-based access control model

This system has several users that are classified into several roles or groups. Each role has different permissions. It aims to maintain data security that irresponsible people cannot change.

Administrator: The administrator is a super-user assigned to oversee the system to fit the procedure. Administrators can also remove users who are not responsible, such as uploading non-compliant content or sending racist-friendly comments. Additionally, the administrator can also add new users and grant administrator privileges so they can help with their work. Administrators can also manage all the content that appears on this system and remove any inappropriate content, so content on this system can be guaranteed.

Contributor: contributor is a user who has an account on this system. Everyone can sign up to be a contributor to this system for free. Once the user is registered on the system and logged in, the contributor can upload photos and his system description via the mobile app. Additionally, the contributor may also view content that another contributor has uploaded, and they can also provide likes and comments on the content. Finally, suppose the contributor finds content that does not comply with the rules. In that case, they can also report the content to the administrator.

Guest: the guest is a regular user who does not have an account on this system, so the guest can only view content uploaded by contributors on this system, but they cannot give like, comments, or report content.

Based on their role, administrators and contributors have an essential role in this system. The administrator keeps the system up and keeps the content that the contributor uploads can be guaranteed. At the same time, the contributor is the source of the data, those who upload photos of his building to the system so that everyone can see it.

4.2 Client-side model

Everyone has used mobile devices like smartphones, tablets, and others. So using a smartphone on this system will significantly facilitate users accessing and contributing to this system. On the client side, this system uses mobile-based applications. The approach to developing mobile applications is by putting forward some elements, including spatial awareness with the user-based location, making it easier to use the application.

Social elements create space for sharing photos and interacting with comments and likes on content other users upload.

Promotional elements are done by sharing the features with other social media users such as Instagram, Facebook, etc. This feature is essential because it can be used to promote the place to more people. It is also expected that more shares on other social media will attract people to use this application, so the data and content that this application can collect can also increase.

Based on Figure 2 describe how mobile applications work in this study. Mobile apps are used by a contributor to send object images and related information to the server; the mobile application can also see the object of photos that another user has submitted. The process of communication between mobile applications and servers through web service. The data format sent from the server to the mobile application is JSON.

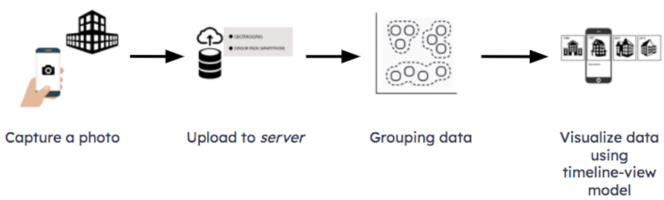


Fig. 2. The workflow of the proposed application

When the user has finished taking photos using the camera through the app, then the app will retrieve the date and time information when the picture is taken. Furthermore, the application requires a GPS sensor to get information about where the photo is taken. Moreover, information about a user who takes a picture can also be included. After all the required information has been obtained, the data can be stored in the photo metadata. Thus, the photo consists of details about the photo's time, place, and owner. Such information will make it easier to visualize data using a timeline view concerning place and time.

Figure 3 shows our proposed system workflow. First, the system collects photos of buildings that users have sent to the server. Next, the server will process and group the data based on the similarity of the data. Finally, after the data has been grouped successfully, the system will visualize it into a timeline-view layout.

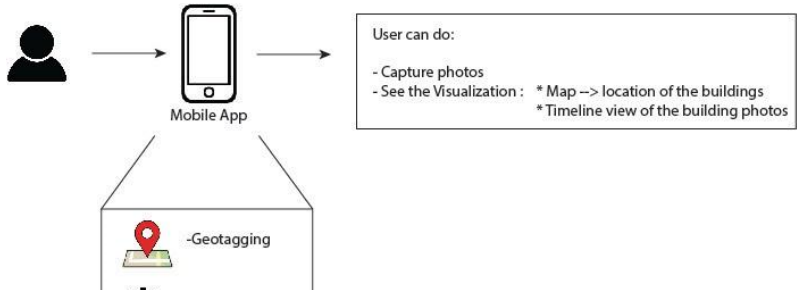


Fig. 3. The workflow of historical building timeline mobile application

Figure 4 describes how mobile applications work on this system. Users can use the mobile app to take pictures of buildings using the smartphone's camera or select photos from the collection of galleries stored on the smartphone. The application automatically adds information related to the user's location into the image to be sent to the server using geotagging with EXIF format. For data visualization, there are two methods: map and timeline view. A map is used to facilitate the user to know the location of the building. The timeline view allows users to see and understand the transformation or events in the building.

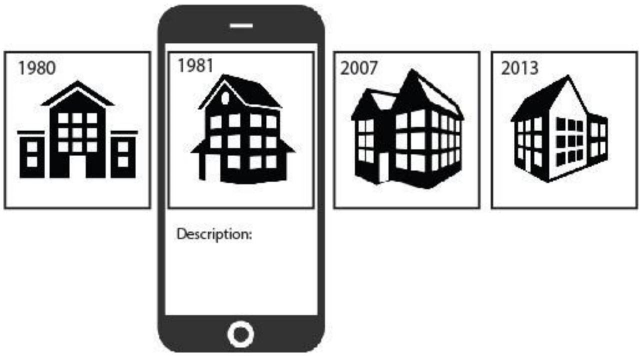


Fig. 4. The illustration of timeline-view on the mobile application

Figure 6 is the illustration of the timeline view on the mobile application. The mobile application will display photos of buildings grouped by the building and sorted by the date when the photo was taken.

We apply some rules to group the photos. The first rule is by name. We also measure the similarity of the name entered by the user. Next, we compare the name entered by the user with the title already stored on the database server. Next is the rule based on distance. Finally, we set the threshold to limit the maximum distance the location is detected as a unique place from the other photos. We used a 75-meter limit in this study.

Figure 5 and Figure 6 are the user interfaces of the mobile application on our system. Figure 5 is the user interface of the reporting page; the contributor must fill in several fields, such as the name of the building and details related to the building. Figure 6 shows some of the user interfaces of the timeline view in the mobile application. The timeline view will display building photos grouped by place and year.

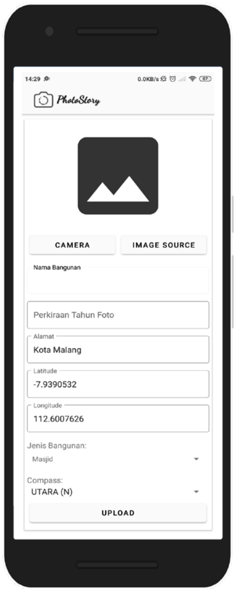
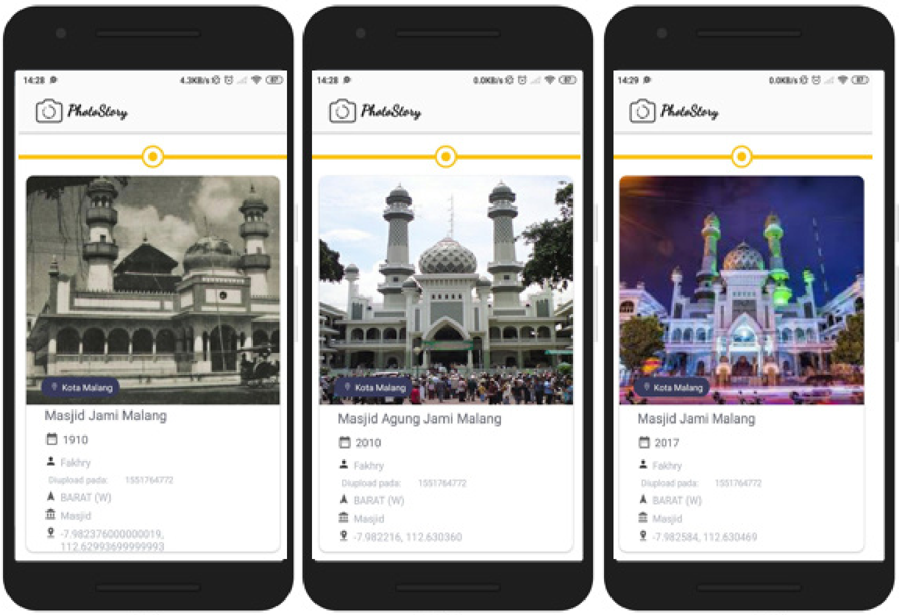


Fig. 5. The user interface for uploading data from mobile application to server



(a) (b) (c)

Fig. 6. The user interface of the timeline-view page in the mobile application. (a) Malang jami' mosque in 1910 (b) Malang jami' mosque in 2010 (c) Malang jami' mosque in 2017

4.3 Server-side model

Based on Figure 7, the server-side consists of several applications, including web service, web administration, and web visualization. Web service serves as a communication bridge between the server and client sides. The communication between the server side and client side uses a JSON data format. So when the mobile application requests data, the app will call the function on the web service. The web service will process it, access the database to get the desired data, and send it back to the mobile application. Then on the server side, there is also a web administration. Administrators use web administration to monitor the contents of the system, such as user management and a reporting page. The web is accessible only to administrators with an account on this system.

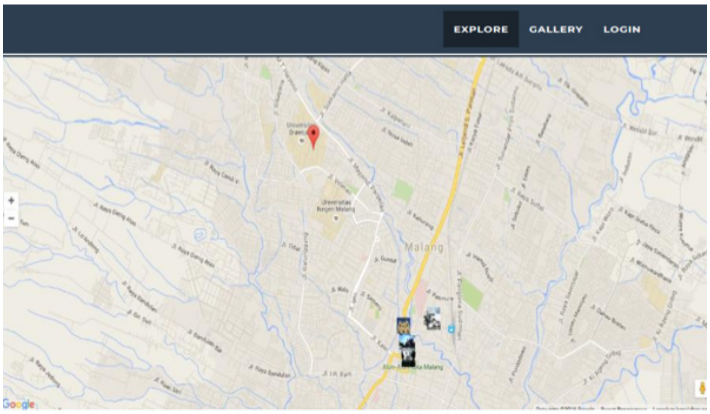


Fig. 7. User interface of the historical buildings map view

In comparison, web visualization is the web used to display image data buildings and can be accessed freely without having to log in. For example, Figure 7 shows a map visualization to show the locations of buildings. In contrast, Figure 8 shows a list of buildings the system has grouped.

Fig. 8. User Interface of the buildings photos list view

5 Discussion

The PhotoStory application has been tested with several users (respondents). In the first test, the researchers made comparisons on some similar applications. Things that will be compared are related to public view (whether access to the public or only certain people), the ability of any user to upload data, platform scope (data scope, international, national, local), support mobile application, Data visualization model (timeline, map, list) and grouping of content. In the second test, we use the usability method to test the convenience of our proposed application with other applications.

We asked 10 participants to experience our proposed and other applications for our case. The questions focus on learnability, efficiency, memorability, errors, and satisfaction when using the application. The participants were chosen based on their backgrounds, such as historians and tourism. First, participants were asked to try all the applications that we have listed. Then, after they had tried the whole application, the participants were asked to fill out a questionnaire related to usability.

Figure 9 shows the results of usability testing for our proposed application. The proposed application obtained 87% on learnability, 94% on efficiency, 84% on memorability, 83% on errors, and 88% on satisfaction. The result shows that the application we propose can be used easily by users.

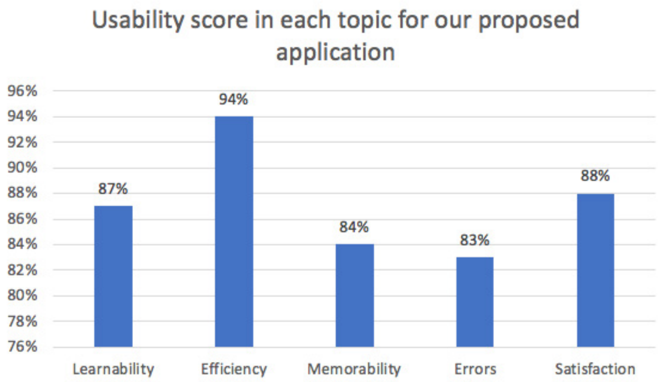


Fig. 9. Usability score for the proposed application

Table 4 summarizes the average value of the usability test performed on our proposed application and culture gate. The comparison in Table 2 shows that users can be more helpful in historical reading content and develop them sequentially based on time. Users can also easily understand the transformation that occurs in the buildings when the photos of the building are arranged based on a timeline-view layout.

Table 4. The average score of the usability test

Platform	Average score
Proposed Application	87,27
Culture Gate [5]	73,775

6 Conclusion

In facilitating the learning process, mobile technologies can be implemented in environmental education [15]. Mobile devices offer various facilities that can be used to help humans in their lives. Including the use of mobile phones as a medium of communication for the deaf [16]. Or can also be used as a medium for learning traditional musical instruments [17], as in this study, which utilizes mobile devices to preserve historic buildings. There are many applications for historical heritage that offer some visualization methods for displaying data, such as using lists and maps. The method we propose is to add a timeline view to data visualization has successfully increased user satisfaction. Based on the usability tests that have been done, the system obtained a value of 87,27%, with the Efficiency parameter getting the highest value among other usability parameters, which was 94%. Users can easily understand the buildings' transformation and condition by viewing photos arranged in a time sequence using a timeline-view layout. As a result, users also feel more aware of the historical buildings.

Moreover, when this application is used, the existing photo data in this application can also be utilized for analysis of the condition of the building so that the application can help the historical building preservation program. On the other hand, classifying content based on name, place, and distance can help visualize the data more effectively in the timeline-view approach. Further research is required for future works to make the content grouping approach more efficient and the application even better by adding error handling to minimize user errors.

7 References

[1] UNESCO, "World Heritage List Statistics," *The United Nations Educational, Scientific and Cultural Organizations (UNESCO)*, 2021. http://whc.unesco.org/en/list/stat (accessed Sep. 01, 2021).

[2] B. Jensen, "Instagram as Cultural Heritage: User Participation, Historical Documentation, and Curating in Museums and Archives through Social Media," in *2013 Digital Heritage International Congress (DigitalHeritage)*, 2013, pp. 311–314. https://doi.org/10.1109/DigitalHeritage.2013.6744769

[3] Y. Jie, J. Dhiraj, and L. Jiebo, "Connecting people in photo-sharing sites by photo content and user annotations," *Proc. - 2009 IEEE Int. Conf. Multimed. Expo, ICME 2009*, pp. 1464–1467, 2009. https://doi.org/10.1109/ICME.2009.5202779

[4] E. Union, "Europeana Collections," 2017. http://www.europeana.eu/portal/en (accessed Jul. 31, 2021).

[5] Z. Koukopoulos and D. Koukopoulos, "A Participatory Digital Platform for Cultural Heritage within Smart City Environments," in *Proceedings - 12th International Conference on Signal Image Technology and Internet-Based Systems, SITIS 2016*, 2017, pp. 412–419. https://doi.org/10.1109/SITIS.2016.71

[6] N. P. Libraries, "Home Page - The Prow," 2017. http://www.theprow.org.nz/ (accessed Jul. 31, 2021).

[7] P. M. N. S. A. Basid, H. Tolle, and F. Ramdani, "Designing module e-complaint system based on geotagging and geofencing," *Int. J. Interact. Mob. Technol.*, vol. 11, no. 3, pp. 113–129, 2017. https://doi.org/10.3991/ijim.v11i3.6557

[8] E. Widarti, D. Eman, and Suyoto, "User-Centered Design for Mobile Apps Guide Service Heritage Tourism in Indonesia," *Int. J. Interact. Mob. Technol.*, vol. 14, no. 16, pp. 87–100, 2020. https://doi.org/10.3991/ijim.v14i16.11312

[9] X. Y. and J. M. S. Xia, X. Gong, W. Wang, Y. Tian, "Context-Aware Image Annotation and Retrieval on Mobile Device," in *2010 Second International Conference on Multimedia and Information Technology*, 2010. https://doi.org/10.1109/MMIT.2010.89

[10] C. Stefani, C. Busayarat, J. Lombardo, and L. De Luca, "A Database of Spatialized and Semantically-enriched Iconographic Sources for the Documentation of Cultural Heritage Buildings," in *18th International Conference on Virtual Systems and Multimedia*, 2012, pp. 165–172. https://doi.org/10.1109/VSMM.2012.6365921

[11] G. Liestøl, "Situated Simulations: A Prototyped Augmented Reality Genre for Learning on the iPhone," *iJIM - Int. J. Interact. Mob. Technol.*, vol. 3, 2009. https://doi.org/10.3991/ijim.v3s1.963
[12] U. Kulkarni, S. M. Meena, S. V. Gurlahosur, and U. Mudengudi, "Classification of cultural heritage sites using transfer learning," in *Proceedings - 2019 IEEE 5th International Conference on Multimedia Big Data, BigMM 2019*, 2019, pp. 391–397. https://doi.org/10.1109/BigMM.2019.00020
[13] Z. Koukopoulos and D. Koikopoulos, "Implementation and Usage Scenarios of a Participatory Platform for Cultural Environments," in *6th International Conference on Digital Heritage Euromed*, 2016. https://doi.org/10.1007/978-3-319-48496-9_1
[14] N. A. N. Ahmad and M. Hussaini, "A Usability Testing of a Higher Education Mobile Application Among Postgraduate and Undergraduate Students," *Int. J. Interact. Mob. Technol.*, vol. 15, no. 9, pp. 88–102, 2021. https://doi.org/10.3991/ijim.v15i09.19943
[15] M. Kalogiannakis and S. Papadakis, "Combining mobile technologies in environmental education: a Greek case study," *Int. J. Mob. Learn. Organ.*, vol. 11, no. 2, p. 108, 2017. https://doi.org/10.1504/IJMLO.2017.10005249
[16] R. Dermawi, H. Tolle, and I. Aknuranda, "Design and Usability Evaluation of Communication Board for Deaf People with User-Centered Design Approach," *Int. J. Interact. Mob.*, vol. 12, no. 2, pp. 197–206, 2018. https://doi.org/10.3991/ijim.v12i2.8100
[17] F. Permana, H. Tolle, F. Utaminingrum, and R. Dermawi, "Development of Augmented Reality (AR) Based Gamelan Simulation with Leap Motion Control," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 12, pp. 120–135, 2019. https://doi.org/10.3991/ijim.v13i12.9270

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