An effective approach to develop location-based augmented reality information support

Komang Candra Brata[1], Deron Liang[2]
[1]Department of Computer Science, Universitas Brawijaya, Indonesia
[2]Department of Computer Science and Information Engineering, National Central University, Taiwan

Article Info

Article history:

Received May 7, 2018
Revised Mar 12, 2019
Accepted Apr 3, 2019

Keywords:

Augmented reality
Location based service
Navigation
Usability
User journey

ABSTRACT

Using location-based augmented reality (AR) for pedestrian navigation can greatly improve user action to reduce the travel time. Pedestrian navigation differs in many ways from the conventional navigation system used in a car or other vehicles. A major issue with using location-based AR for navigation to a specific landmark is their quality of usability, especially if the active screen is overcrowded with the augmented POI markers which were overlap each other at the same time. This paper describes the user journey map approach that led to new insights about how users were using location-based AR for navigation. These insights led to a deep understanding of challenges that user must face when using location-based AR application for pedestrian navigation purpose, and more generally, they helped the development team to appreciate the variety of user experience in software requirement specification phase. To prove our concept, a prototype of intuitive location-based AR was built to be compared with existing standard-location based AR. The user evaluation results reveal that the overall functional requirements which are gathered from user journey have same level of success rate criteria when compared with standard location-based AR. Nevertheless, the field study participants highlighted the extended features in our prototype could significantly enhance the user action on locating the right object in particular place when compared with standard location-based AR application (proved with the required time).

Corresponding Author:

Komang Candra Brata,
Department of Computer Science,
Universitas Brawijaya,
Veteran Street No. 8, Malang 65145, East Java, Indonesia.
Email: k.candra.brata@ub.ac.id

1. INTRODUCTION

Augmented Reality (AR) is a powerful user interface technology that augments the user's real-life environment with the computer generated data. This technology works by overlaying the real world with virtually generated data renders such as graphics, text, video, sound that provide the enriching and complementing reality with immersive capability to view content information, navigate, communicate and change the way users interact with their environment [1]. This technology of AR is implemented in a variety of areas for over 10 years to help user access additional information for a specific task without getting distracted [2-6].

Location-Based AR seeks to smoothly link the physical location coordinate with data processing environments that make a user can see POI (Point of Interest) annotation of the particular landmark in a real environment. Using location-based augmented reality for navigation can greatly improve user action to reduce the travel time especially when the apps designed for pedestrian usage. A major issue with using location-based AR for navigation to a specific landmark is their quality of usability, especially if many information objects are displayed on the active screen at the same time. The lack of usability of this application's type could be confusing and difficult to understand for the person who does not know the place especially for a foreigner, furthermore this issue can make users fail to find their destination. Figure 1 reveals the usability indication issues on the presentation view of standard or common solutions of location-based AR on smart phone that use sensor based tracking. Based on that issues, there is a need to consider the user experience as a definitive factor in requirement specification for develop a location-based AR application.

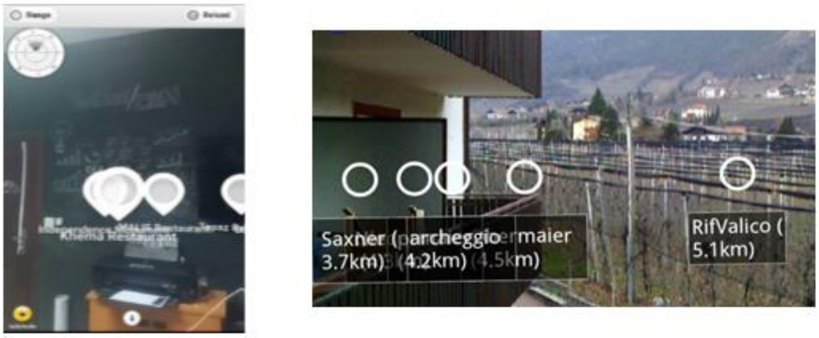


Figure 1. Standard location-based AR presentation interface of Wikitude [7] and Mixare [8]

User-centered design process could optimize the traditional development process by bringing an "early-fail" to support rapid prototyping. This process includes participatory design to capture user behaviors. Rather than focusing on fully developing a single idea to high fidelity system, the user centered design process makes rapid progress on multiple ideas toward a minimum viable product by quickly eliminating flawed concepts [9].

A user journey map (UJM) is a recently emerged method for designing and assessing user experience in the product design field. This map adds a third dimension feature to a traditional user persona by focusing on a diachronic outline of a user and a product [10]. Dove et al build a lightweight journey mapping framework that led to new insights about how customers were using a product [11]. Previous works on usage of user journey map also prove that a journey map can illustrate a graphic visualization of a user's experience with a product [12-14].

In this paper, we explain an implementation of user journey map as a tool for rapidly convert user experience into software requirements to design a prototype of mobile location-based AR systems that can help users to find their destination intuitively. This research use user journey map to capture pain and behavior of the user using the following metrics: (1) effectiveness, (2) learnability, and (3) satisfaction. In addition, this research also conducts a comparative study between standard location-based AR application and improved location-based AR application with new requirements that considering human factor from user journey map result.

2. RESEARCH METHOD

Developing an effective location-based AR application for instance is not simply a matter of technical wizardry. This is due to the fact that physical and real-life objects of the user's environment take an increasing role in the design.

2.1. Usability oriented approach

Usability is defined as the quality attribute of user interface in a product such as mobile applications. Usability definition is often referenced into "effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment". Usability attributes are precise and measurable key factors of the usability. Usability attributes include e.g. that systems are easy and fast to learn, efficient to use, easy to remember, allow rapid recovery from errors and offer a high degree of user satisfaction. According to this definition, a product's usability key factors are determined as follow [15]: Effectiveness-whether users can achieve what they want to do with the product. Efficiency-how long it takes them to achieve it. Satisfaction – their feelings and attitude towards the product.

In this research, we intend to use usability oriented approaches to extract the information which could be useful for a user and will focus on three aspects that we have found relevant when designing AR applications: field study, user scenario and user journey mapping.

2.2. Field study

Ethnographic study is mostly naturalistic approach that can be used to analyze the user activities and behaviors [16]. Based on this approach, we involved the user in designing phase of this AR application. User behaviors place a strong emphasis on the necessity for design phase. This method commonly called a participatory design [17]. We collect our user's persona before we conduct the designing phase. A persona is a useful tool for describing user profile of a specific target group, it convey the relevant demographic, psychographic, behavioral, and needs-based attributes [18]. When users are involved in design phase, it means that the design methodology cannot be limited to a description of the task at hand. The methodology has to consider the whole environment (physical, technical and social) in which the task is performed. This requires an in-depth analysis of user's activities in order to understand their successful work practices and to identify the limitations of the current way of working. Number of participants that involved in the usability field study and testing can be varied. Number of participants that involved in the usability field study and testing can be varied. Faulkner prescribes that 10 participants will discover as many usability issues as more number of individuals will do. The involvement of 10 contributors is capable enough to give the proportional value-to-cost ratio in usability testing [19]. According to the literature studies, we involve 10 participants in this research.

The participants were chosen based on four characteristics: (1) they have been using Android smartphone, (2) understand English, (3) can read directions and (4) doesn't know exact location on the map. Background questionnaire was given to validate that all participants meet the characteristics. All participants are undergraduate and postgraduate students who have good understanding in English and have been using Android smartphone in supporting their daily activities. Participants' ages are ranged from 20 to 28 years old.

2.3. User scenario

As a way to concretely embody a view of user's actual and future activities, scenarios have proven very useful in mobile AR design projects [20]. Particular scenarios will enable the description of how AR devices would affect the way of users carry out their individual and collective task activities. The scenario is outlined in several tasks in sequential order. Each participant will be responsible for completing all specific instruction scenarios. Scenarios included in this research were divided into two tasks, Blind Search and Directed Search. We test all of the scenarios on the same hardware device and the same distance location then we measure and compare the result between standard location-based AR and our approach prototype. In Blind Search, participants will be asked to do some actions. Table 1 depicts the detail activities on blind search scenario.

Table 1. Task: blind search

Task	Description
1	Start the App
2	Find the random location that given to the participant in average 300 m radius.
3	Use AR explore views, to see the augmented POI.
4	Go to the given location that appear in the AR screen.

In Directed Search, the participant will be asked to do some actions that shown in Table 2. We test the scenario on the same hardware device and the participant will choose one destination that located in same range distance then we measure and compare the result between standard location-based AR and our approach prototype. Table 2 shows the detail activities on directed search scenario.

Table 2. Task: directed search

Task	Description
1	Start the App
2	Open Map View mode and select one place that appear on the map when distance in average 300 m radius.
3	Enter AR explore view, see the augmented POI.
4	Go to location that appear in the screen.

When they did the scenario's task, we observed and mapped the process by using data collection forms to record each step transaction.We evaluated the time and success rate of the journeys and after that, a specific data collection form will be used to record the steps needed to complete each scenario.

Procedures to follow for each scenario: 1) Describe each step of the process to each participant as an application user. 2) Rate user personal success and elapsed time in completing each step. 3) Record all users personal reactions to the experiences when they complete the scenario using questionnaires. 4) Let users use any and all resources at their disposal to complete these scenarios with one exception. Do not confer with each other.

2.4. User journey mapping

Visualization and mapping techniques are valuable tools for communication and collaboration in user experience professional domain. It can transform system requirements and processes into visible dimensions and create clarity about what elements within the service system have contributed to the experience [21]. In software development process, it is often that software designers become subjectively entranced to what they like and prefer and such questions about funding, time and procedure to conduct the tests, or even the test requirement are emerging [22].

User journey map (UJM) produced a visual picture of how users had experienced their traveling to a particular destination using Location-based AR Applications. Detail components of a user journey map are described in [23]. A user journey map is a table with user's steps through time on the horizontal axis, and along the vertical axis there are metrics or themes category for analysis. The steps on the horizontal axis will vary according to the problem domain, but the vertical axis usually stays the same [24]. Figure 2 depicts our user journey map framework.

	Enter Camera AR View.	Search POI Location	See information about POI Location	Navigate to POI location	In destination
Action	▪ Open Camera ▪ Select location marker ▪ Press AR view button	▪ Get Direction ▪ Get Device location	▪ Get POI ▪ Read POI Information	▪ Chose desired POI ▪ Walk to destination	See POI with 0-5m distance remaining.
Question	▪ Is camera ready? ▪ Why Camera Glitch? ▪ Do I have location?	▪ Am I in right direction? ▪ The Sensors work properly?	What are importance information?	▪ Where the exact location that appear on screen?	-
Happy Moment	▪ App show Camera View. ▪ Camera Screen work properly.	Easily find POI about desired location	Get information clearly.	▪ Can guest the POI exact location ▪ Have Guidance that assist to Find Location.	POI the same with real object location.
Pain point	▪ Camera not working without alert warning. ▪ Too long calibration when camera error.	▪ POI doesn't appear ▪ POI doesn't fit the real object ▪ Too much POI in the screen and too crowded ▪ Confuse when following camera view perspective	Difficult to read Information when 2 or more POI overlap each other.	▪ No clue about how to get POI ▪ POI only show straight direction, not showing when to turn left or right. ▪ Difficult to find exact POI, actually when location behind another building	No notification appear when user is near destination.
Opportunities	Create warning when error occur and Build feature that allow user to calibrate the camera and sensor.	▪ Build integrated compass and allow user set location radius ▪ Map mode that allow user see from another perspective	Create adjustments mechanism for POI that appear on screen.	Build features that can step by step guide user to POI location.	Ensure that user get notification when he near destination.

Figure 2. Result of user journey map

In this research, we use action, question, happy moment, pain point, and opportunities as vertical axis parameters. Actions: the thing the user needs to do to move to the next step. Questions: the things that the user needs answering before they'll be willing to move to the next step. Happy moments: positive, enjoyable things that improve the experience. Pain points: frustrations and annoyances that spoil the experience. Opportunities: design enhancements that you could implement in a new product, that address any of the problems identified.

2.5. Insight from UJM

From collected scenario data in our user journey map, the pain point and opportunities regions are main concern of our insight. Pain point and happy moment regions give a clue about problems that user must face when using standard location-based AR application. We propose our solution based on user pain in opportunities region. Nevertheless, in this study we are not dealing with all opportunities which are located in the User Journey Map. Table 3 shows our requirements summary from user journey insight.

Table 3. Opportunities summary from UJM

#	Problem	Opportunities
1	Difficult to read Information when 2 or more POI overlap each other.	Create adjustments mechanism for POI that appear on screen.
2	No clues about how to go to POI location	
3	Users can't read information clearly when 2 or more POIs overlap each other.	Create a new feature that can step by step guides user to POI location.
4	Difficult to find exact POI, actually when the location is behind another building	
5	Users don't know how far the distance they should take to the POI.	Give meaningful notification when user are approaching their destination

2.6. Prototype description

The study is designed for evaluating the impact of using the User Journey Map to gather insights in order to improve the user experience when participants are using location-based AR for the navigation tasks. From Table 3, we can specify the main requirements that needed to be built in order to improve location based AR experience. To prove our finding, the mobile AR prototype which was developed in our research aims at providing assistance to the users with regard to accessing and receiving time-table information about the bus transport network of Zhongli District, Taiwan.

The application architecture of this prototype adopts the 3-tier architecture for data transactions. It involves three key concepts: use web service as data service, modularity in software development, for superior performance and portability, it separates the components of application servers that containing business logic functions and database servers that containing databases physically into different tiers/layers (due to its considerable transportation data size). There are hundreds of routes in Zhongli District, Taiwan and each route have many bus stop objects. As study scope, this application only generate the augmented reality POI objects in one route that chosen by the user.

The proposed location-based AR application sends a request to the server and then generates the POIs based on data in the database. After the application gets response data and phone location, it synchronizes the POI with smartphone orientation and movement sensors data. Thus, the POIs marker can be rendered and displayed accurately on the smartphone screen presentation through superimposing virtual objects over real-world bus stop locations. The detailed development methods and system architecture of the proposed prototype clearly described in previous research [25].

2.6.1. Adjustment mechanism of POI that appear on screen

The application should focus on the device's location and orientation. This means if a user are in a particular place and pointing the device in a particular direction, it shows only the virtual landmark object annotations that corresponding to that place and direction that matched with user radius distance and landmark coordinate on the database as shown in Figure 3. The user also needed information about real-time distance. With sensors based data, the distance between the user and the POI landmark can be determined by Haversine formula calculation [26].

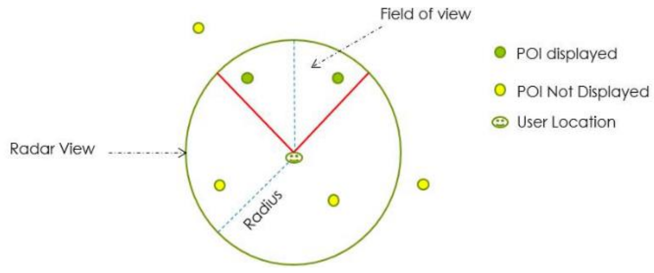


Figure 3. Mechanism to adjust the POI that appear on screen

The number of POIs that shown in application are determined accordingly based on the radius from the user location. First, it reads the device location then perform POI data request to the web service which is used to process the client request and determine the data source. Next, response data from web service will be computed and transformed to augmented reality marker in client side. Finally, the generated marker will be displayed based on device orientation which is captured using smart phone sensors. Additionally, if there are two or more POI objects in the same direction, another method to separate more important augmented reality POI from less important ones, is to occlude the ones that are farther away from the user's current location. Given the fact that the more distant POIs are most likely less important than the closer ones, it is not a severe loss of information if a shape gets fully hidden by a closer one as shown in Figure 4.

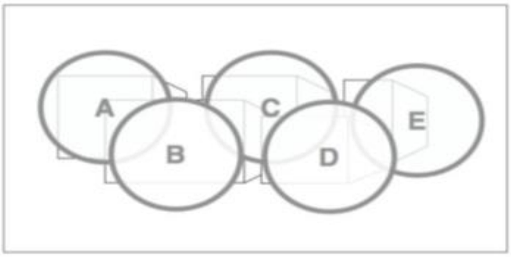
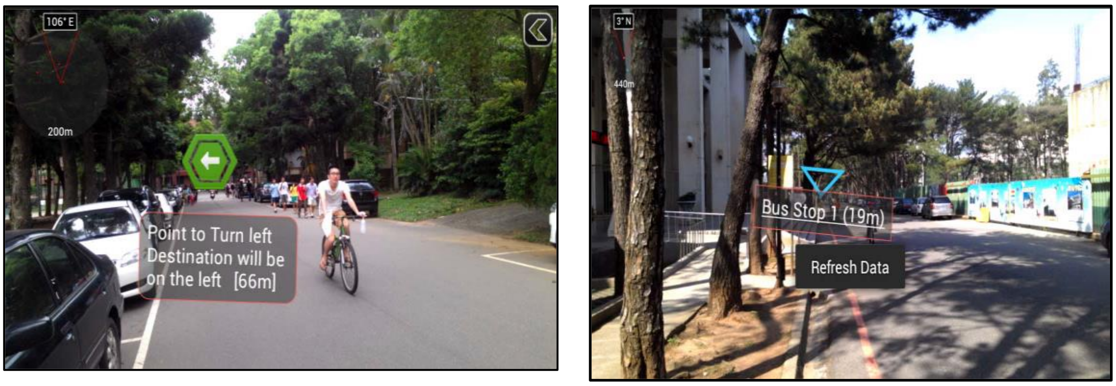


Figure 4. Illustration of the occluded POI markers adjustment

2.6.2. Step by step navigation view

To give the user a more dynamic way of finding his route, views based on augmented reality could be offered to him. We design UI/UX transition of our prototype based on [27] that reveal in location-based AR scenario, users are easily identifying the annotation objects when they have highlight on a landmark, direction arrows to next waypoint and the remaining distance information to a particular POI. On top of user camera feed of his smartphone, additional helpful information for his current routing segment would be displayed. This approach makes our proposed prototype can provides step by step navigation rather than display all required POI on the same screen as in standard location based AR. Figure 5 depicts the detail user interfaces in the location-based AR prototype which was used in this study.



(a) (b)

Figure 5. The user interfaces of proposed prototype (a) step by step guidance and (b) POI change shape based on user distance

The different marker icons illustrate the POI of respective bus stops and the direction guidance that user should follow to enter the bus stop destination. All of them are accompanied by an info window that contain detail information about the destination and next waypoint to turn right or turn left as well as its distance from the current user's location. An intuitive feature also added to informs that the user are approaching the destination. The POI marker icon will change automatically when the user is near (less than 20 m) to the final target destination location as shown in Figure 5b.

2.7. User evaluation

As described in IEEE standards [28], validation needed to check whether all software functionalities have satisfied the requirements. To evaluate the feasibility of our approach to gather software requirements, we compare both standard AR and proposed prototype which was built based on our insight from user journey map to demonstrate the usability improvement of the location-based AR application. In the following, we test several case studies on top of an Android platform. To gather detailed insights into navigation performance, usability testing is used. We ask the participants to do the same task scenarios as in field study phase with both applications, standard AR and our proposed prototype in blind search and directed search. With step-by-step navigation marker in the proposed AR prototype, a user would see at least one next waypoint and his final target. Therefore, the user only need to follow the POI guidance to go to the destination. Oppositely, when using the standard location-based AR, a user don't have a clue about when to turn left or turn right to go to destination.

3. RESULTS AND ANALYSIS

The usability testing is the most often utilized method for verifying and validating the quality of software [29]. In IEEE standard validation [30], time and success rate mentioned as parameter for efficiency and correctness, so we use travel time and success rate as efficiency indicator to comparatively evaluated our approach in comparison with standard location-based AR. From the scenario testing, the following measures were captured: 1) Required time: defined as the time between the POI being displayed on the AR screen until the participant indicating their arrival on POI location. 2) Success rate: defined as the number of correct road selections for the entire route, expressed as a percentage. 3) Degree of usability: defined as the value of each usability factors effectiveness, learnability, and satisfaction. Captured using a questionnaire that completed after all conditions had been experienced and presented as a mean ranking. 4) General comments: Captured using a bespoke questionnaire at the end of the scenario testing, within the discussion and interview section.

The usability testing is done with the questionnaire on participant assessment of our prototype application. We performed a survey based on [31] to get some feedbacks and user experiences about our prototype. The questionnaires cover three factors of usability, i.e. effectiveness, learnability, and satisfaction. Testing result of each scenario and summary of participant's questionnaire about usability factors degree that ranged from 0 to 100 are summed up in Table 4.

Table 4. Average value of descriptive statistics testing result

Variables	Test Conditions	
	Standard Location AR (Mean) / (SD)	Proposed Location AR (Mean) / (SD)
Time (minutes) :		
- Blind Search	14.9 / 2.13	5.40 / 1.40
- Directed Search	7.86 / 1.10	5.12 / 0.86
Success Rate :		
- Blind Search	100%	100%
- Directed Search	100%	100%
Questionnaires :		
Q1 : This system prototype will allow me to find a location faster	73.6 / 5.08	94 / 9.66
Q2: The information that overlaid on camera screen is helpful.	79.1 / 5.36	90 / 10.54
Q3: Learning to operate the application prototype is easy for me	68.1 / 3.28	91 / 9.94
Q4: I think that using the prototype fits well with the way I like to use a mobile device.	83.3 / 8.03	87 / 11.60
Q5: Whenever I make a mistake inside the prototype, I could recover easily and quickly	75.1 / 4.72	93 / 9.49
Q6: Overall, I'm satisfied and I think this system complete task is helpful.	79.3 / 1.64	95 / 7.07

The results indicate that the general pattern is similar, meaning items were scored significantly better in the prototype of location-based AR that developed based on UJM insights. Although both of the apps could help user to find the destination with same level of success rate, considering the total time for performing each scenario condition, participants completed the experiment task faster with proposed location-based AR system, for blind search scenario (Mean=5.4, Min= 4, and Max= 8.83) while the standard location-based AR is (Mean=14.9, Min=12, and Max=20). Directed search scenario reveals the same result that proposed location-based AR also have better time (Mean=5.12, Min=4, and Max=7) than standard location-based AR (Mean=7.86, Min=6.6, and Max=10). This data proves that presenting POI as a step by step navigation can be better understandable to user rather than display many augmented POI information on screen at the same time. Participants also made similar comments in favor of our AR approach and against the standard location-based AR, supporting the result of time and success rate. "[Standard location-based

AR] could lead to lots of errors easily. It was confusing, hard to follow, and time consuming." One participant who fails to complete the scenario noted that "it was not easy to find the POI object location because it was placed behind another building especially in blind search scenario". Although our proposed location-based AR system was rated more highly than the standard one, the majority of participants made several comments about drift problem. One participant stated, "The proposed system prototype is very intuitive to use but sometime there is a mismatch between the objects and the augmentations so need precise GPS coordinate," and another noted that "even the POI augmentations were not exactly matching (on the right object), but with information on the screen, I could easily guess the right location."

4. CONCLUSION

This paper proposes user journey mapping method to gather software requirements of a location-based augmented reality application for pedestrian usage. The main objective of user journey mapping is considering user-centered perspective while investigating the real user's experience and their personal requirements. To prove our concept, both standard location-based AR and the prototype of our approach had been tested and compared in an uncontrolled environment and a real-time environment as well. Overall, the two applications tied with respect to success rate criteria. Nevertheless, standard location-based AR interface still need to resolve usability issues. The results also revealed strong preferences to the similar application developer that the key to make location-based AR can efficiently support its user was how the POIs are presented in the smart phone screen. The amount of POIs in the augmented reality can be confusing, users are easier to learn the step by step POI scenario. Additionally, the overall functional requirement that gathered from user journey map could significantly enhance the user action (in terms of reducing travel time) when using our proposed location-based AR presentation, compared to standard location-based AR system. This result also proves that user journey map is an effective tool for communication and collaboration in early phase of software development process. Insight form user journey could help developer team to build rapid software requirements that consider human factors to develop a more robust and reliable system that have good usability level as well.

REFERENCES

[1] R. T. Azuma, "A Survey of Augmented Reality," *Presence Tele operators and Virtual Environment*, pp. 355-385, 1997.
[2] S. Lin, *et al.*, "Ubii: Physical World Interaction through Augmented Reality," *IEEE Transactions on Mobile Computing*, vol/issue: 16(3), pp. 872-885, 2017.
[3] S. J. Henderson and S. K. Feiner, "Augmented reality in the psychomotor phase of a procedural task," *Proc. 10th IEEE Int. Symp. Mixed Augmented Reality*, pp. 191-200, 2011.
[4] D. Schmalstieg and D.Wagner, "Experiences with handheld augmented reality," *Proc. 6th IEEE ACM Int. Symp. Mixed Augmented Reality*, pp. 3-18, 2007.
[5] W. Narzt, *et al*., "Pervasive Information Acquisition for Mobile AR-Navigation Systems," *Proceedings of the Fifth IEEE Workshop on Mobile Computing Systems & Applications*, pp. 1-8, 2003.
[6] K. C. Brata, *et al.*, "Pengembangan Aplikasi Mobile Augmented Reality untuk Mendukung Pengenalan Koleksi Museum," *Jurnal Teknologi Informasi dan Ilmu Komputer (JTIIK)*, vol/issue: 5(3), 2018.
[7] Wikitude, "Wikitude Application," 2017. Available: http://www.wikitude.com/.
[8] Mixare, "Mixare–Open Source AR Engine," 2017. Available: http://www.mixare.org/.
[9] J. Kramer, *et al.*, "A user-centered design approach to personalization," *Communications of the ACM*, vol/issue: 43(8), pp. 44-48, 2000.
[10] R. Baker, "Personas and Journey Maps," *Agile UX Storytelling. Apress, Berkeley, CA*, pp. 75-80, 2017.
[11] L. Dove, *et al.*, "Lightweight journey mapping: The integration of marketing and user experience through customer driven narratives," *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems. ACM*, 2016.
[12] H. Moon, *et al*., "A design process for a customer journey map: A case study on mobile services," *Human Factors and Ergonomics in Manufacturing & Service Industries*, vol/issue: 26(4), pp. 501-514, 2016.
[13] J. Li, *et al*., "Application of User Experience Map and Safety Map to Design Healthcare Service," *Advances in Human Factors and Ergonomics in Healthcare. Springer International Publishing*, pp. 195-204, 2017.
[14] K. C. Brata and M. S. Hidayatulloh, "An idea of intuitive mobile diopter calculator for myopia patient," *TELKOMNIKA (Telecommunication Computing Electronics and Control)*, vol/issue: 17(1), 2019.
[15] M. Speicher, "What is usability? a characterization based on ISO 9241-11 and ISO/IEC 25010," *Technical Report; Department of Computer Science Technische Universitat Chemnitz*, 2015.
[16] W. E. Mackay, *et al*., "Reinventing the familiar: exploring an augmented reality design space for air traffic control," *Proceedings of the SIGCHI conference on Human factors in computing systems. ACM Press/Addison-Wesley Publishing Co.*, 1998.

[17] W. E. Mackay and A. L. Fayard, "Designing interactive paper: lessons from three augmented reality projects," *Proceedings of the international workshop on Augmented Reality: placing artificial objects in real scenes: placing artificial objects in real scenes. AK Peters, Ltd*., 1999.
[18] W. Lidwell, *et al.*, "Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design," Rockport Pub, 2010.
[19] L. Faulkner, "Beyond the five-user assumption: Benefits of increased sample sizes in usability testing," *Behavior Research Methods, Instruments, & Computers,* vol/issue: 35(3), pp. 379-383, 2003.
[20] L. Nigay, *et al*., "Mobile and collaborative augmented reality: A scenario based design approach," *Human Computer Interaction with Mobile Devices,* pp. 241-255, 2002.
[21] F. Segelström, "Communicating through visualizations: Service designers on visualizing user research," *Conference Proceedings ServDes. 2009; DeThinking Service; ReThinking Design; Oslo Norway 24-26 November 2009. No. 059. Linköping University Electronic Press*, 2012.
[22] B. Lok, "Evaluating user interfaces," *in Human Computer Interaction Chapther 4, Department of Computer & Information Science & Engineering, University of Florida*, 2014.
[23] G. Bernard and P. Andritsos, "A Process Mining Based Model for Customer Journey Mapping," 2017.
[24] T. Howard, "Journey mapping: A brief overview," *Communication Design Quarterly Review,* vol/issue: 2(3), pp. 10-13, 2014.
[25] K. C. Brata, *et al.*, "Location-Based Augmented Reality Information for Bus Route Planning System," *International Journal of Electrical and Computer Engineering,* vol/issue: 5(1), pp. 142, 2015.
[26] R. W. Sinnott, "Virtues of the Haversine," *Sky and telescope*, vol/issue: 68(2), pp. 158, 1984.
[27] A. Bolton, *et al.*, "An investigation of augmented reality presentations of landmark-based navigation using a head-up display," *Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, ACM*, 2015.
[28] IEEE Computer Society, "IEEE Standard for Software and System Test Documentation," *IEEE Std 829™*, 2008.
[29] P. Zaharias and A. Poylymenakou, "Developing a usability evaluation method for e-learning applications: Beyond functional usability," *Intl. Journal of Human–Computer Interaction*, vol/issue: 25(1), pp. 75-98, 2009.
[30] IEEE Computer Society, "IEEE Standard for System and Software Verification and Validation," *IEEE Std 1012™-2012*, 2012.
[31] T. Olsson and M. Salo, "Online user survey on current mobile augmented reality applications," *Mixed and Augmented Reality (ISMAR), 10th IEEE International Symposium*, pp. 75-84, 2011.

BIOGRAPHIES OF AUTHORS

Komang Candra Brata is a Lecturer in the Department of Computer Science, Universitas Brawijaya. He received the MSc degree in Department of Computer Science and Information Engineering, National Central University, Taiwan in 2014 as an International Dual Degree Master student between University of Brawijaya, Indonesia and National Central University, Taiwan. He completed his Bachelor degree in Department of Informatics Engineering, University of Brawijaya, Indonesia in 2012. His research interest are in the areas of software engineering and information technology, distributed systems, mobile application development, deep learning and augmented reality.

Deron Liang is a Professor in the Department of Computer Science and Information Engineering, National Central University, Taiwan. He received a BS degree in electrical engineering from National Taiwan University in 1983, a MS and a PhD in computer science from the University of Maryland at College Park, USA in 1991 and 1992 respectively. He also holds joint appointment with the Institute of Information Science (IIS), Academia Sinica, Taipei, Taiwan, Republic of China. He was with IIS from 1993 till 2001. Dr. Liang's current research interests are in the areas of software fault-tolerance, system security, distributed systems, object oriented and system reliability analysis. Dr. Liang is a member of ACM and IEEE.