Indonesian Journal of Computer Science
ISSN 2549-7286 (*online*)
Jln. Khatib Sulaiman Dalam No. 1, Padang, Indonesia
Website: ijcs.stmikindonesia.ac.id | E-mail: ijcs@stmikindonesia.ac.id

Meta-Interface Analysis for Interaction in Mobile Augmented Reality

Ardiman Firmanda[1,7], Sritrusta Sukaridhoto[2], Hestiasari Rante[3], Cahya Miranto[4,8], Evianita Dewi Fajrianti[5], Sandi Prasetyaningsih[6]
ardimanfirmanda@live.com, dhoto@pens.ac.id, hestiasari@pens.ac.id, cahyamiranto.social@gmail.com, evianita08@gmail.com, sandi@polibatam.ac.id
[1,2,3,4,5]Politeknik Elektronika Negeri Surabaya
[6,7,8]Politeknik Negeri Batam

Article Information

Submitted : 14 Jul 2022
Reviewed : 26 Jul 2022
Accepted : 17 Aug 2022

Keywords

Augmented Reality, Augmented Intelligence, Cultural Heritage, Meta-UI, User Experience

Abstract

Mobile Augmented Reality has expanded including the cultural heritage sector. Among the options offered is the digitization of cultural heritage. Multiple technical breakthroughs has implemented, including hand gesture recognition and body tracking, into mobile augmented reality systems. The success of these improvements depends on a good user interface. Meta User Interface (Meta-UI) allows significant information to be displayed without interfering with system operation. The results of the analyses that the Meta-UI user interface could aid users in employing hand gestures and body motion capture on this mobile augmented reality without any issues and could deliver information about batik efficiently. PIECES Framework testing confirmed this, with a satisfaction score of 4.40 to 4.55. Using the PIECES Framework concepts and questionnaire that focus on user satisfaction with mobile augmented reality, the score indicates that the user is satisfied.

A. Introduction

In recent decades, mobile augmented reality technology has quickly adopted a variety of features [1]. It is manifest in education sectors to scientific applications [2], entertainment [3], navigations [4], and education regarding cultural heritages [5]. Augmented reality (AR) presents the user with a version of their daily reality that has been improved with a user interface, coupled with effects, modified, and otherwise shown to the user [6]. Between virtual reality (VR) and actual reality, augmented reality (AR) conveys and displays virtual information such as films, photos, and three-dimensional (3-D) objects in the real camera view. With the processing capabilities of mobile devices constantly evolving, interactive mobile augmented reality has become a promising technology [7].

A system's user interface is essential, especially mobile augmented reality (MAR). The value of the user interface is significant for developing quality applications and should be considered holistically. The User Interface contains specific user interaction components that provide the user with the functionality to communicate with the interactive system [8][9]. An effective User Interface affects this sense of presence because it can provide convenience and intuition and make it easier for users to receive the desired results from using the system [10]. Some of the user interfaces available in mobile augmented reality do not have general guidelines/design principles for user interface design [11]. So that the user interface is made based on a literature review and draft of the system and then tested on users for getting feedback. In this research, we present an analysis of the use of the user interface for interaction with the Meta-UI approach in Mobile Augmented Reality Education Virtual Try-On Batik Apparel [5].

The primary objective of this study is to analyze the possibility provided by implementing a meta user interface solution into the interface design of an Augmented Reality application for cultural heritage education.

B. Related Woks

Currently, many studies on mobile augmented reality are made by bringing their respective UI design approaches. Isma Widiaty et al develop markerless augmented reality to display information about the philosophy of batik. The application implements a non-Diegetic user interface that has a batik motifs recognition feature to identify batik motifs and gain information about related batik [12]. The next research in Mobile Augmented Reality was conducted by Fajrianti et al. [2], this research raises the theme of education in the field of Health, where users can learn the structure of human organs interactively. Media control and information are presented to the user using a meta-UI approach that makes it easy for users to operate and capture the information.

Other research in the domain of cultural heritage, such as Mobile Augmented Reality edutainment applications for cultural institutions by Chatzidimitris et al [13]. This research focuses on the historical study of the Lesvos Museum of Industrial Olive Oil Production. In this study, participants scanned markers placed throughout the museum to obtain information and 3D visualizations. This research employs a non-diegetic user interface to display information.

Subsequent research by Jevremovic et al. [14]. Against the backdrop of the closure of the national museum in Serbia for ten years. Researchers took the initiative to create an AR application that can function as a medium for the general public to recognize cultural heritage objects in the museum. With the system scanning the QR code that has been provided, users can see the cultural heritage objects. With a diegetic user interface approach, this AR application presents good visuals and gets a positive response.

a) Graphical User Interface Type

In augmented reality, User Interface services allow users to engage in the virtual world. Providing users with enough information, making the system operation clear, and fostering a sense of immersion are all examples of excellent interface services. There are button elements, instructional and information text, and graphics in the typical interface that carry information and allow users to engage. For immersive AR technology, giving the best experience for users to reuse isn't just about visual graphics, it's about providing the finest experience possible. The interface has a clear interface, eliminating ambiguity that might add to the problem of perplexity in the development of the interface itself. User comprehension of a system rule can be boosted by a good, rapid and responsive interface.

There are four types of immersive user interfaces based on the terminology of Fagerholt and Lorentzon [15], Figure 1.

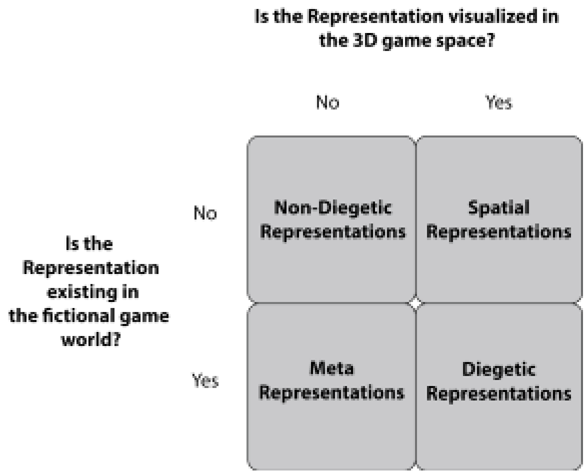

Figure1. Four interface type Fagerholt and Lorentzon's terminology

1) Spatial interfaces are three-dimensional components that may or may not be present in immersive technologies.
2) Diegetic interface, an interface that enters the world of immersion. The user can engage with the characters or objects in immersive worlds.
3) A non-diegetic interface is visible to the user but not to the immersive world's characters.
4) A meta interface is typically a 2D interface displayed to the user as an effect, such as pop-up information, but they are not physically displayed within the scene.

Meta UI is similar to diegetic UI. Both elements are justifiable as existing in the immersive world, but Meta UI exists on a 2D plane. Similar to spacial and non-diegetic UI, the character is unaware of this UI element existing. This element does not interfere with the reality of the Immersive world in the system. Meta UI helps create a stronger sense of immersion in the virtual world. It's a good way to include UI elements without interrupting the immersive world and scenario of the system. Meta UI takes a character experience and maps it to a UI element on screen for the player to more easily view and interact with it.

b) Meta-UI in Immersive Application

The reality world is presented to the player in a streamlined and organized manner by Meta-UI. It is effective when the user can interact with something minor or complex that the player should have command over or a clear perspective on. To design a user interface, we take an approach that considers the demographics of end-users and users to determine the necessary interface elements. Using Meta-UI, we then create user- and end-user-centric designs to determine the level of task completion. We define the appropriate Meta-UI components and entities using this methodology.
Figure 2 is a system design using the Meta-UI Implementation approach in Augmented Reality Applications [16].

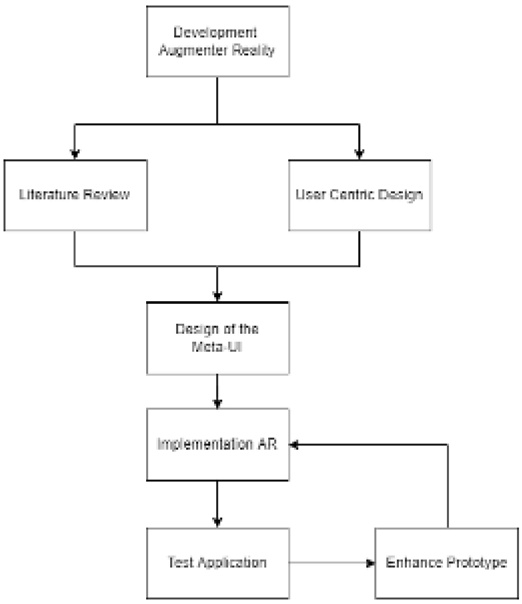

Figure2. Meta-UI design approach to Augmented Reality

To determine the requirements of an application, a literature review is required. Data collecting is important in this process; one example is the target user and the reason why this application was created. The target user in this project is the general public who owns a smartphone and wants to experiment with new ways to design and explore batik without needing to go to a current batik exhibition. The target audience for this application is batik artisans who want to experiment with new approaches to market their batik items. Additionally, in this research, the User Centric Design approach [11] is applied in the UI design process. There are nine steps in the UI design process with

User-Centric Design; the first is to specify what type of system will be constructed.

The Augmented Reality system that will be built is a mobile virtual try-on system for batik apparel by implementing hand gesture recognition as a controller. Then the next step is to determine the scenario, function, and workings of the system that will be used. Meta-UI is designed to act as a visual medium for delivering information from the instructions given by the system as well as batik information displayed.

c) Interaction in Immersive Application

In their research, Mostafazadeh et al. [16] studied and evaluated interface design for mixed reality interactions. Mostafazadeh et al. analyze and design user-centric Meta-UIs that support the operation of metasystems. Analysis, design, prototype construction, and assessment of 3D-based meta-user interfaces for supported scenarios in ambient settings is a substantial contribution.

For immersive apps, there is a constant need for both 2D and 3D components. Building the immersive system included three stages: creating 2D and 3D assets, the development process, and compiling and deploying the finished product. The basic idea is to create a half-curve-shaped user interface with all visuals centered around the user. Increased user engagement and improved accessibility were the goals of this strategy. In order to improve user experience, there is a design stage method for immersive applications including Task, Environmental, User, and System characteristics [9]. An immersive application designed for users, the program must be easy to use, entertaining, and educational.

C. Analysis of Meta-Ui for Cultural Heritage Mobile Augmented Reality

Proper interface design will improve user experience and user immersion in using the system. It is important to evaluate the system that has been made so that it can continue to be developed according to user feedback. Designing a good user interface depends on the system's requirements and the type of information or data to be presented. In the mobile augmented reality system, there is no definite solution for what type of user interface is good to implement; Meta, diegetic, non-diegetic, and spatial UI have their functions. This is due to the mobile device screen size limitation, so a good type of user interface is one that can provide information acceptable to the user and provide an immersive user experience when using the system.

Researchers used an early development version of the mobile augmented reality virtual try-on for the batik apparel platform [5] as an evaluation material in this study. This platform can run on smartphone devices with the iOS operating system and has a minimum spec chipset type A12 Bionic. In this system, almost all user interfaces use the meta-UI type as an intermediary between the system and the user. The use of meta-UI is initiated when the system is started, the user is presented with an Instructional UI which serves to guide the user on the first use of this system (Figure 3).

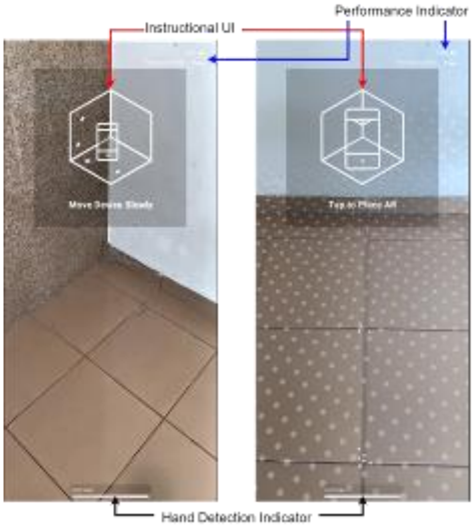

Figure 3. Meta-UI on Instructional UI Scene

In Figure 3, there is an instructional UI, “Move Device Slowly” which directs the user to move the smartphone device used so that the smartphone can scan the surface using the camera to recognize the floor and wall surfaces. This is needed as a condition for the virtual 3D mannequin object to have a floor mat to display. Then, the next instructional UI displays the "Tap to Place AR" instruction and provides a visual of white dots indicating the surface has been scanned and mapped so that the virtual 3D model object is ready to be displayed according to the instructions. both the instructional UI "move device slowly" and "tap to place AR" are designed as animations so that the user can follow the motion of the instructional UI to increase the user experience. A UI performance indicator in the top left corner will display in every scene requiring this UI. UI performance indicators display frames per second and processing time as information for users of the system's current state.

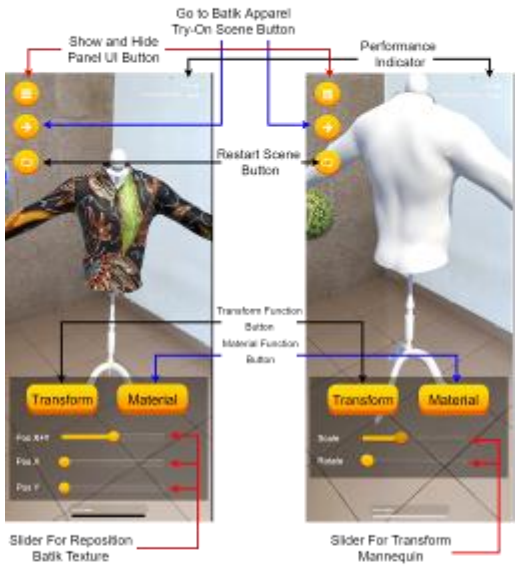

Figure 4. Meta-UI on Desain Batik Scene.

After the user completes the instructions given by the system, the user is then directed to the Batik design scene. It can be seen in Figure 4 that in this scene, the Meta-UI elements are mostly used to adjust the 3D objects in the scene. There are button and slider elements in the scene. In this scene, the user is free to adjust the mannequin model's size and reposition the batik motif according to the user's wishes. This function can be displayed by pressing the "Show and Hide Panel UI Button" button because the UI panel for customizing 3D objects in the scene is hidden in the default position. The "Transform" or "Material" button in the user interface scene changes the slider function according to the button's label. When pressed, the transform button will bring up two sliders with the function of scale and rotation for the 3D model of the mannequin, and users can adjust them according to their wish and convenience. The Material button, when pressed, will display three sliders with the function of shifting the batik motif in the X position, the Y position, and the batik motif density scale.

The system built by implementing the hand gesture recognition function, which is useful as a controller on the platform. The hand gesture recognition function will be active when the camera from the mobile device captures a visual of the user's hand and will activate the trigger when the hand forms a registered gesture. In this system, there are three registered gestures such as release (Figure 7), grab (Figure 9), and touch (Figure 6). Release gesture is a default gesture that functions like a mouse pointer, when the user touches a 3D virtual object that has been programmed, the system will respond to give feedback to the user following what has been in the scenario. Gesture touch is used to separate the batik texture ball, and gesture grab is used to bring the Batik texture ball to the mannequin to apply batik texture to the mannequin.

(a) (b)

Figure 5. Meta-UI on Instructional UI Touch Gesture Scene.

In Figure 5, Meta-UI is implemented in the Instructional UI, which gives commands to do touch gestures and touch the Batik texture ball. Like the

Instructional UI before it, in this scene, it is designed with animated examples of how the user should perform the command. The dotted direction arrow in Figure 5(a) depicts the movement of the hand direction animation. Figure 5(b) represents the final animation condition where the hand touches the Batik texture ball.

(a) (b) (c)

Figure 6. Interaction with Hand Gesture to Split Batik Texture Ball.

Figure 6 accurately simulates the instruction Instructional UI in Figure 5. The process starts from Figure 6(a) to 6(c). the exciting thing when doing the simulation is when the hand touches the batik texture ball and the batik texture ball becomes transparent. This provides information if the hand has touched a 3D virtual object on this system.

(a) (b)

Figure 7. Meta-UI on Selection Batik Motif Scene.

In Figure 7, Meta-UI also plays a role in the batik selection scene. After the balls of batik texture are separated using touch gestures in the previous process, users can see information on the type of batik provided to be applied to the model. Figure 7(a) shows that the hand has been detected by the camera system but has not yet touched a 3D virtual object, namely a batik texture ball. Figure 7(b) is the condition when the hand touches a virtual ball with a 3D batik texture. The difference in conditions when touched is to display a UI panel that conveys information about the currently selected Batik motif.

(a) (b) (c)

Figure 8. Meta-UI on Instructional UI Garb Scene.

The next implementation of Meta-UI is the scene for applying Batik texture to the mannequin (Figure 8). This UI also displays animated instructions for what the user should do. Instructions start from Figure 8(a) through 8(c). Using the Grab gesture gives users an experience as if they are picking up something to move their position.

(a) (b) (c) (d)

Figure 9. Interaction with Hand Gesture to Apply Batik Texture on Mannequin.

Figure 9 accurately simulates the instruction Instructional UI in Figure 8. Users can try to apply Batik texture to the model using the method in Figure 9. After batik is applied to the model, the user can reposition the Batik motif using the slider on the existing user interface, as shown in Figure 4. Implementing the hand gesture recognition function on the system can also increase the user's experience in using it because not many mobiles augmented reality use this function in their work system.

(a) (b)

Figure 10. Meta-UI on Try-On Batik Apparel Scene.

In addition to the hand gesture recognition function, this system is also equipped with body motion capture. The body motion capture function is used to read the user's body. Then the body's position will be attached to Batik apparel that was designed with batik motifs in the previous batik design scene. When the user moves to the Try-On Batik apparel scene, the user is given an instructional UI, "Find a Body to Track" as shown in Figure 6 (a). The Instructional UI will disappear when the system detects the user's body was entering the camera range. The system will display a virtual 3D Batik apparel object and then paste it onto the user's body as if the user is wearing the Batik apparel. In this system, the size of the batik apparel is still done by the system automatically, so the user stands and poses. The same thing with the hand gesture recognition function, the body motion capture function is also rarely encountered in mobile augmented reality, so users can experience a new user experience using mobile augmented reality, especially this system.

D. Analysis of User Experience on Meta User Interface

In this chapter, we will explain the results of the user satisfaction analysis related to the implementation of the platform's meta-user interface with a questionnaire based on the PIECES framework. The questions asked are related to the experience of using the platform. Calculation of satisfaction value in the PIECES Framework using the formula 1.

$$Ave = \frac{Total\ Score}{N} \quad (1)$$

Ave = average satisfaction

Total Score = Total score of the questionnaire

N = Number of respondents

Table 1. Rule Average Satisfaction Pieces Framework

Value Range	Satisfaction Predicate
1 – 1.79	Very Dissatisfied
1.8 – 2.59	Not Satisfied
2.6 – 3.39	Sufficiently Satisfied
3.4 – 4.91	Satisfied
4.92 - 5	Very Satisfied

Twenty questions refer to the PIECES Framework domain, which focuses on user experience and the implementation of Meta-UI on the system.

Table 2. Number of Question by PIECES Domain

Variable	Number of Questions
Performance	5
Information and Data	3
Economics	3
Control and Security	3
Efficiency	3
Service	3

Using 30 respondents with requirements and smartphone users who have tried the platform that has been provided. The researcher uses the average value mapping in table 1 to map the values obtained, whether the user is satisfied or not.

Table 3. Result of Satisfaction

	System Satisfaction
Performance	4.55
Information and Data	4.41
Economics	4.43
Control and Security	4.40
Efficiency	4.44
Service	4.51

In table 3, the satisfaction score obtained on the platform performance gets the predicate of being satisfied, as evidenced by the score on a scale of 4.40 – 4.55. This shows that the use of Meta-UI does not interfere with the user's UX, but the use of Meta-UI can increase satisfaction using the system, as seen from testing the level of satisfaction using the PIECES Framework.

E. Conclusion

Creating a mobile augmented reality system for cultural heritage, especially Batik apparel, by implementing virtual experiment functions, hand gesture recognition, and body tracking that combines all three functions on a mobile platform is a new thing and challenging. In addition, using the Meta-UI interface approach also gets a positive value for the user experience. It is proven by the value obtained using the PIECES Framework method, namely 4.40 – 4.55. For systems that run on smartphone devices, the use of meta-UI with characters that provide detailed information is suitable for this system. It has simple visuals so that the system can provide information and a good user experience to users without having to be disturbed by the interface design elements.

F. Acknowledgment

We would like to thank the Politeknik Elektronika Negeri Surabaya and Politeknik Negeri Batam for supporting and making this research possible.

G. References

[1] R. Kaviyaraj and M. Uma, "A Survey on Future of Augmented Reality with AI in Education," 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS), pp. 47-52, 2021.

[2] E. Fajrianti et al., "Application of Augmented Intelligence Technology with Human Body Tracking for Human Anatomy Education", International Journal of Information and Education Technology, vol. 12, no. 6, pp. 476-484, 2022.

[3] J. Hernández and A. A. Navarro-Newball, "Augmented Reality Board Game to Favor Water Source's Preservation," 2019 International Conference on Virtual Reality and Visualization (ICVRV), pp. 271-272, 2019.

[4] Y. Gu, W. Chidsin and I. Goncharenko, "AR-based Navigation Using Hybrid Map," 2021 IEEE 3rd Global Conference on Life Sciences and Technologies (LifeTech), pp. 266-267, 2021.

[5] A. Firmanda, S. Sukaridhoto, H. Rante, and E. D. Fajrianti, "Preliminary Development of Virtual Try-On Platform for Batik Apparel Based on Mobile Augmented Intelligence Technology," in Electrical and Computer Engineering, Cham, pp. 40–54, 2022.

[6] D. Schmalstieg and T. Höllerer, "Augmented reality: Principles and practice," 2017 IEEE Virtual Reality (VR), pp. 425-426, 2017.

[7] N. Islam and R. Want, "Smartphones: Past, Present, and Future," in IEEE Pervasive Computing, vol. 13, no. 4, pp. 89-92, 2014.

[8] Roto, Virpi et al. "User Experience White Paper – Bringing clarity to the concept of user experience.", 2011.

[9] O. Dabor, E. Longford and S. Walker, "Design Guidelines for Augmented Reality User Interface: A Case Study of Simultaneous Interpretation," 2019 11th Computer Science and Electronic Engineering (CEEC), pp. 164-166, 2019.

[10] Salomoni, P., Prandi, C., Roccetti, M. et al. Diegetic user interfaces for virtual environments with HMDs: a user experience study with oculus rift. J Multimodal User Interfaces 11, 173–184, 2017.

[11] A. Dunser, R. Grasset, H. Seichter, and M. Billinghurst, "Applying HCI principles to AR systems design," in 2nd International Workshop on Mixed Reality User Interfaces 2007 (MRUI'07) IEEE Virtual Reality, 2007.

[12] I. Widiaty, I. Yustiawan, Y. Wibisono, A. Abdullah, C. Abdullah and L. Riza, "Implementation of markerless augmented reality method to visualise philosophy of batik based on Android", Pertanika Journal of Science and Technology, vol. 26, no. 3, pp. 1383 - 1400, 2018.

[13] T. Chatzidimitris, E. Kavakli, M. Economou and D. Gavalas, "Mobile Augmented Reality edutainment applications for cultural institutions," IISA 2013, pp. 1-4, 2013.

[14] V. Jevremovic and S. Petrovski, "MUZZEUM — Augmented Reality and QR codes enabled mobile platform with digital library, used to Guerrilla open the National Museum of Serbia," 2012 18th International Conference on Virtual Systems and Multimedia, pp. 561-564, 2012.

[15] E. Fagerholt, M. Lorentzon, and S. Bjo¨rk, "ERIK FAGERHOLT MAGNUS LORENTZON," sweden, p. 124, 2009.

[16] A. Mostafazadeh, A. A. N. Shirehjini, S. Daraei, N. Khojasteh, and S. Shirmohammadi, "A meta user interface for interaction with mixed reality environments," in 2015 IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE), Oct. 2015, pp. 1–6, 2015.