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AR Based User Manual for Receipt Printer Configuration

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***Abstract*—Augmented Reality (AR) allows the user to place 3D virtual content to real world environment. By implementing AR technology, the configuration of receipt printer can be taught to the users easily. The users will be able to get the instructions according to the orientation and position of the printer components based on the targeted real-world space and view the step-by-step guidance on configuring the printer in AR. Therefore, the purpose of the project is to develop a mobile application that assists the users to view and learn to configure the printer using AR technology without the need of referring to user manual. There are three phases that have to carry out. Firstly, to conduct a preliminary study on the previous works related to AR user manual to get ideas on the ways to implement AR complementing the traditional user manual purposes. The second phase is to develop an application on related GUI. Lastly, the third phase is to integrate the proposed application with marker-based AR to display instructions based on distance and orientation in real world space. The output of this project has been evaluated through a user testing process on the user acceptance. The usability results show the users are satisfy with AR user manual for printer configuration as compared to the traditional printed user manual. The user acceptance results also show the AR used in this application helps the user in configuring the printer easily.**

***Keywords*—Augmented reality, user manual, printer configuration**

I. INTRODUCTION

Augmented Reality (AR) allows user's view of reality to be combined with virtual content that appears to be spatially registered in the physical word [1]. AR provides an interactive experience where it enables interaction between virtual objects and real objects. The 2D object that display on flat screen which is represent in virtual can be display in 3D real environment with the presence of AR.

Many implementations in both Virtual and Augmented Reality systems have proven to be effective methods for teaching humans to perform tasks that otherwise would be extremely costly or risky to replicate in the real world, using advanced computing graphics [2].

Traditional user manual, also known as a technical communication document or manual, is designed to help users who are using a specific device [3]. It contains written guide and supports images. Screenshots of the interface will be included for computer application meanwhile for hardware manuals, it includes clear simplified diagram. The limitation of traditional user manual is it offers only 2D images in the manual for reference where the user has limited view and cannot physically interact with the device. It is time consuming to fix configure by referring to user manual [4].

With the presence of AR, a user able to view and interact with the virtual object aligned with the real environment. This project provides an interactive way using smartphone based on AR technology that aims to allow unskilled users to efficiently complete a task such as loading the media into the printer and changing the battery of the printer.

The aim of the project is to develop a mobile application that assist users to view and learn to configure the printer using AR technology without the needs of referring to the user manual. The project had been discussed comprehensively into several sections, which are: literature review, methodology, implementation, evaluation and lastly conclusion.

II. LITERATURE REVIEW

AR allows the user to view the surrounding real world and superimpose virtual object with the real world. AR is an immersive experience of a real-life environment in which computer-generated perceptual input is used to improve the objects in the real world. Instead of completely overriding the reality, AR add object to the reality [5], [6]. Therefore, AR supplements reality, rather than completely replacing it. any system that are combine real and virtual environment, interactive in real time and register in three dimensions are consider as AR [1], [7], [8]. The technology can be identified as AR when it has these three characteristics which is combine real and virtual, is interactive in real time and is registered in three dimensions. In this literature parts, several issues are discussed according to the AR processes and also the printer manual that been based by this project.

A. Stages of AR Development

The main objective of AR is to identify the device camera location in the real environment and the virtual object's relation to the scene. It finds the relation of the known real-world object and finds the transformation such as translation and rotation to the camera [9]. there are four main stages for developing Augmented Reality which are scene capture, scene identification, scene processing and visualization of AR [10]. Firstly, in scene capture stage, a single photogram is processed which has captures by cameras or videos. The device that is used to capture scene is the device used to perceive the real world surrounding which will be used to augment. Next stage of AR development is scene identification techniques. There are two ways of detecting the real scene which is marker based and non marker-based [10]. A marker-based AR are required to register an image or object which represent as marker in real world, the marker will be tracked by the AR application to register 3D virtual objects. It is one of the most commonly used techniques which usually been utilized in the indoor environment. Also, marker-based AR often been implemented in mobile AR as it requires no powerful devices, and the markers are easily recognized and tracked by the application. While for non marker-based AR, the tracking algorithm detects the objects in the scene such as patterns, colors and other characteristics [11]. Besides, non- maker AR require no predefined marker. The application will be able to recognize the real world object as marker. Non marker-based uses three different mechanisms to identify the scene which is Image recognition, Geo positioning and Hybrid.

B. Handheld AR (HAR) Display

Handheld displays are referring to small computing devices which can fit in our hands. The HAR display uses the video to overlay the virtual content on the real environment. smartphones are the most popular devices for AR applications as these devices contain powerful CPU, camera, accelerometer, GPS and compass which make the smartphones are ideal for AR [12]. However, the device's display size is not a suitable for displaying 3D user interface. Moreover, tablet PCs are more powerful compare to smartphone, but tablets cost more compare to smartphone and it is also not ideal to operate in single hand as smartphone. Tablets required to be operated by using two hands.

C. AR Interaction

Interaction with AR is differed from other technique as it is a combination of real and virtual content [13]. Tangible interaction is user able to directly interact with the known physical object around them to interact with AR. The known object can be marker or hand gesture. A tangible AR interaction where the virtual objects can be interacted by the device's joystick and motion [14]. The user can interact with AR while holding handheld device on one hand and interact with another bare-hand [15].

Next, embodied interaction where the user interacts with the application by using touch screen or moving the device closer to the scene. Touch based interaction is the most commonly used interaction in AR applications. As handheld devices currently available with touch screen interface these reduce the use of physical buttons and stylus input [16].

Next, the printer model used in this project is discussed in details to explain the configuration steps to demonstrated using AR technology.

D. ZQ300 Printer Manual

ZQ300 printer is commonly used in indoor and outdoor. The printer will be used to print receipt and price markdown labels as shown in Fig. 1.

Fig. 1. Receipt printer in ZQ300 Printer [17]

Fig. 2 shows the procedure to install battery into the ZQ300 printer. The angle of the battery should be facing toward the front of the battery well and the clip of the battery facing rear of the camera. Then, slide the battery pack into the well until it clicks into place.

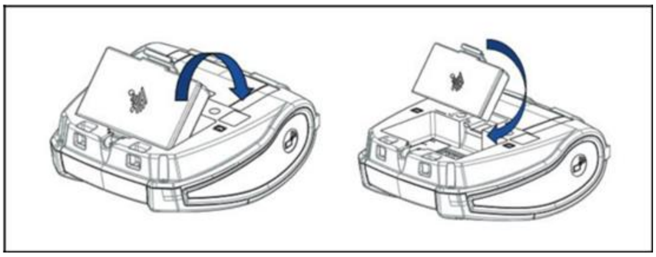

Fig. 2. Steps to install battery into ZQ300 Printer [17]

Besides, loading media into the printer is the most common step needed to be followed when operating ZQ300 printer as shown in Fig. 3. Media is referring to the paper roll which will be used to print receipts. The printer uses thermal paper which require no ink for printing. To load the media into the printer, press the latch on the side of the printer to open the printer's media cover. Next insert the media into the media compartment in the correct orientation. Lastly, close the media cover and verify the media cover click into place to make sure it is correctly placed.

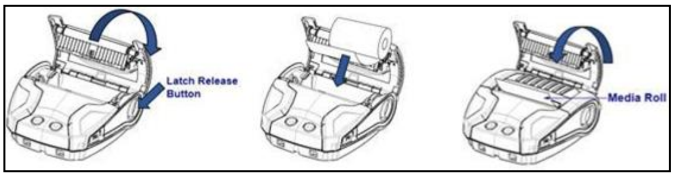

Fig. 3. Steps to load media into ZQ300 Printer [17]

III. METHODOLOGY

The Fig. 4 illustrates the waterfall model used to representing the methodology of this project. It shows the flow of the project from Phase 1 until Phase 4.

Fig. 4. Flowchart of the project using waterfall approach

A. Phase 1

The first phase of this project is to study the implementation of AR. This is a crucial phase to collect more information of the project by reviewing previous works and journal. Throughout this analyzing phase, the implementation of AR in industries and previous works helps the researchers to gain the concept of implementing AR user manual for printer configuration. This phase also clarifies the interaction process along with the AR technology to study the suitability of the implementation of AR in printer configuration. The collected information is used in the next phase.

B. Phase 2

This phase is the main project development to develop an AR application as user manual to configure printer. In this phase, the application is designed using the data that collected in previous phase. Firstly, the 3D model of the printer is created using Blender software based on the printer model (ZQ300). Then, AR marker will be designed by uploading the related component image into Vuforia Target Manager for processing. The features of the marker will be extracted. The marker is then be printed and placed on top of the real printer. The handheld device camera will capture the marker in the real world and calculate the distances between marker using the positioning algorithm with the real-world printer. When user interact by moving the virtual component such as battery, the application provides the instructions about the positioning information accurately either the user moving the virtual component near to the correct position or far from it. The system alerts the user and point the user to the correct configuration position. The application is developed using Unity software with integration of Vuforia SDK.

C. Phase 3

In this phase of integrating AR user manual on application, it focuses on integrating the AR content to the application. The GUI for the application will be developed for easy navigation in the application. Additional information such as printer usage and printer information also been displayed in the application. The step-by-step procedure to configure the printer is displayed on the device screen while the device camera is pointing towards the marker. The tracking process is implemented using Vuforia to display 3D models such as virtual battery and media of the printer and tracking the printed marker to perform the printer configuration tasks. For the next 2 sections, the process of the AR tracking and calibration are discussed in more details.

D. AR Tracking

In this project, a marker-based AR are implemented in the handheld device using Vuforia Engine SDK. Vuforia Engine SDK allows to add advanced computer vision to any application and allow it to recognize things in real world space and interact with it. In this project, print image will be used as trackable target. Vuforia provides the rating to check the trackability of the selected image. The ratings are based on the image's attribute. In order to get high rating, the image has to contain more details, has good color difference, no similar patterns and high-quality format. The higher the rating, the better the marker detection and tracking performance.

For the tracking process, firstly, the handheld device takes the camera input of the real world. The marker which lays on top of the real printer is pointed by the device camera. Image target is detected based on the features that extracted from the target image on run time. Then the features are compared by Vuforia Engine once the device camera recognize the markers in the real word. Next, Vuforia Engine compute the location and orientation of the marker to place the digital content to it. This triggers the display of the virtual 3D printer over the world position with the marker distance in the camera view. Fig. 5 illustrates the process of marker-based tracking process.

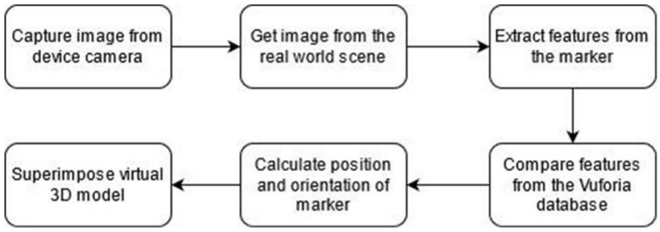

Fig. 5. Marker Based AR Tracking Process

E. Component Position Callibration

The AR marker is placed on top of the printer. Once the user selects the type of configuration that is required for example replace a battery, the AR camera capture the marker on the printer and find which component is held by the user. Once two required markers is detected, the distance of the marker will be calculated based on the position of both markers which place on the printer body and printer component. The instructions on configure the printer and then is displayed on the screen as how the user needed to move and rotate the virtual component based on the calculation of the virtual object position to its required placement. It helps to identify the correct orientation of holding a printer component. Using AR markers, the application detects the correct position of fixing the battery component and provide feedback to the user simultaneously. The flowchart of AR configuration user manual is shown in Fig. 6.

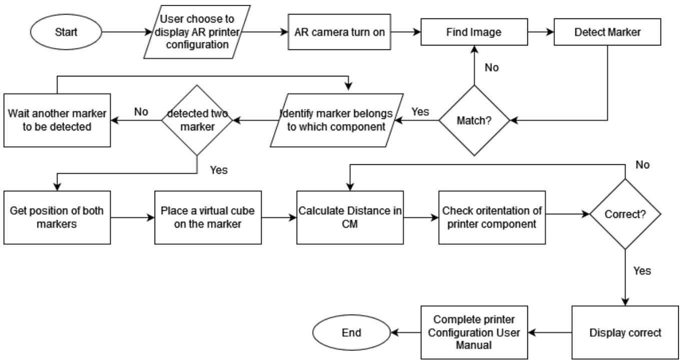

Fig. 6. Flowchart for AR Configuration User Manual

F. Phase 4

This phase is the last phase to test the usability of the application with a range of participants.

IV. IMPLEMENTATION

For this section, the implementtion of the overal project is showed into 4 parts which are: marker detection, integrates the marker position with the virtual component calibration, design of the real printer mockup and full implementation within the handheld device platform.

A. Marker Detection on Printer

AR camera detects marker in the real-world space and place a cube on the marker. The cube game object is used to get the position and orientation of the marker. Fig. 7 shows the labels on the screen 'Battery' and 'Printer Component' are checked when the markers attached to the components are detected. The base class 'DefaultTrackableEventHandler' override by creating subclass 'MyDefaultTrackableEventHandler'. Check the label is achieve by overriding 'OnTrackingFound' method. It verifies the name of the marker with the marker name and check the label on the screen indicating the marker is detected.

Fig. 7. 'Printer Body' checked

B. Implemeting Detection of Accurate Position

The implementation of detecting the accurate position placement of printer component focuses on measuring the distance and orientation of the marker. The distance between two markers is calculated in order to identify the correct placement of printer component to the printer body. The distance of the marker is obtained by distance of game objects that appear once the marker is detected. For example, when marker on printer body and marker on battery component are detected, the application screen displays the feedback in text form as shown in Fig. 8.

For the detailed process, firstly, the marker on printer body and printer battery are detected. A cube game object appears on each marker. A script is added to the cube to update the transform vector and rotation of the cube as shown in Fig. 8. As the value of cube changes when marker move, the position and rotation of the cube will be updated. Based on the position of the cube on each marker, the distance is calculated.

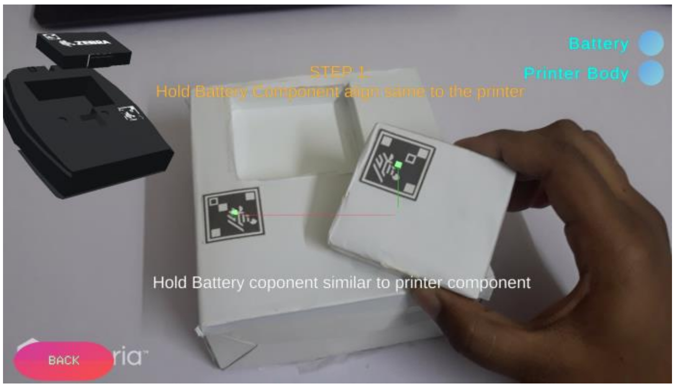

Fig. 8. Display of feedback on screen

Furthermore, the rotation of printer component is detected by comparing normal vector value of the cube. If the cube on both markers are facing the same directions, the Dot product of two normalized vector is 1. ‘Transform.up’ returns the value of normal vector of the cube in Y-axis and ‘transform.right’ returns the value of the cube in X-axis.

Next, the distances between the AR markers shown by a capsule stretched to both the markers. The capsule size is calculated from the distances between both markers on the printer component on each axis as shown in Fig. 9. The temporary variable stores the current size and position of the capsule game object. The distance of both cube game object which placed on the markers will be used to calculate the distance between the marker. The distance will be divided into 2 and transform the position of the capsule game object to it. The distance of markers will be set into the capsule axis scale.

```
position_difference = transform.position;
size_temp = transform.localScale;
pos_tempX = transform.position;
position1 = GamePose1.GetComponent<Pose>().pos;
position2 = GamePose2.GetComponent<Pose2>().pos2;

float distance = position2.x - position1.x;
size_temp.z = distance / 2;
pos_tempX.z = position2.z;
pos_tempX.x = position1.x;
pos_tempX.y = position1.y;
transform.position = pos_tempX;
transform.localScale = size_temp;
```

Fig. 9. Distance of marker by size of capsule game object

The capsule game object in the screen scale according to the distance of the marker. Furthermore, the color of capsule changes from red to orange and yellow according to the correct position of printer component placement. The capsule between two markers is shown in Fig. 10.

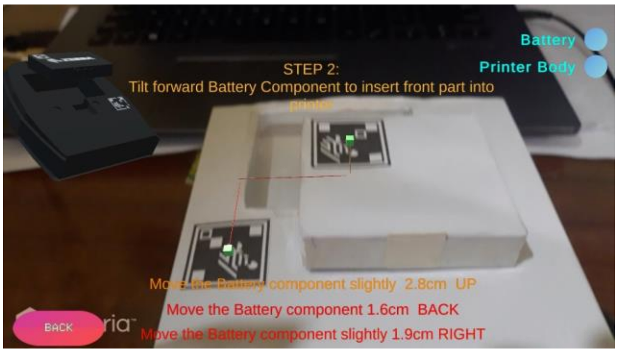

Fig. 10. Capsule gameobject shows distance between marker

C. Implementing AR Tracking in Handheld Device

Vuforia AR SDK imported into Unity3D project. The license key that obtained from Vuforia website is inserted into Vuforia configuration setting in Unity3D. The Vuforia database is loaded in Unity3D for tracking purpose.

Next, the main camera in the scene is deleted and add AR camera prefab is added to the scene. The target prefab is added to the scene to load the marker image from the database. The target image set to the database image configuration is shown in the Fig. 11. All the game objects that appear after target detection is set as child of the target prefab in the hierarchy.

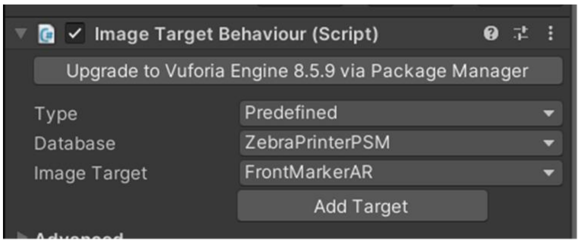

Fig. 11. Marker Target Configuration

D. Designing Receipt Printer Mockup

A prototype design of a receipt printer is created using cardboard to test the application due to the sudden unaccesale of the real printer. The prototype is made of two cardboard boxes. The boxes are covered in a white paper. Firstly, made a hole in the box on both sides to make it as battery compartment and media compartment. The hole is cut according to similar size of the battery cardboard box and media roll size. Next, the cardboard battery is created. A small size of cardboard box is used to represent the battery. The cardboard box is wrapped in white paper and add a small holder on the side of the side of the cardboard to make it easier to pull out of the compartment later. The final look of the cardboard printer body front, back and cardboard battery is shown in Fig. 12.

Fig. 12. Final look of cardboard printer model

V. EVALUATION

As the person in charge at Zebra Technologies could not be reached, this experiment is carried out in cardboard mock up based on the Zebra Printer ZQ310. The cardboard mock up is made by cutting a hole on top which become printer battery compartment and create a new small cardboard box similar to the size of the hole to fit perfectly to be the printer battery. The AR marker stick on the printer body and printer batter as shown in Fig. 13.

Fig. 13. Printer ZQ300 cardboard mock up

A participant sits approximately 30 cm in front the table holding the handheld device in one hand and hold the printer component in another hand for interaction with the cardboard printer as shown in Figure 14. The handheld device is hold about 45 cm away from the cardboard box to view the feedback on the device screen.

Fig. 14. Experimental setup

A. *Pre experiment questionaire*

The testing is conducted among 10 respondents which are four male and six females and these respondents are the ages between 20 to 26 took part in this evaluation. The numbers of participants are enough since this is the preliminary test [18, 19] for the purpose to evaluate the functionality of the initial application. Based on Fig. 15, among 16 respondents, 40% of them are experienced as beginner, 30% of them have intermediate experience using the AR and around 20% of the respondents have no experience using AR.

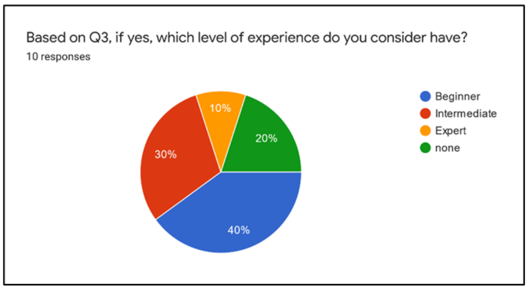

Fig. 15. Participant knowledge of AR

B. *Post Experiment Questionaire*

The post experiment questionaire contains 10 questions. All the data can be summarized as per below:

Majority of respondents' (80%) highly agree that they are can to navigate in the application easily. The remaining 20% of respondents believe that the programme is simple to use.

The first task is to hold the battery in correct orientation. Half of the respondents (50%) strongly agree they were able to hold the battery component align correctly to the printer and 40% of the respondent agree that they were able to hold the battery align correctly to the printer.

Next respondents feedback on the instructions appear on the screen after marker detected. Majority of the respondents (60%) partially agree that they able to follow the instruction. This is because the instruction is continuously updated and detects every movement of the respondents causes changes in the instruction. 10% of the respondent answer they were able to follow the instruction easily as the colour of the text helps the respondent to place the component correctly.

Fig. 16 depicts the responses of the respondents. on the completing the task fixing the battery correctly. Majority of the respondents' (60%) agree that they were able to fix the printer component battery correctly. About 20% of the respondent strongly agree they were able to follow the instruction to complete the task.

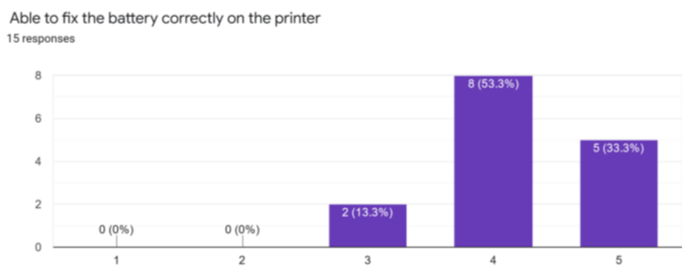

Fig. 16. Feedback on completing the fixing battery

Fig. 17 shows the respondents' satisfaction when using AR user manual. Based on the Fig. 17, 70% of the respondent are agree that they are satisfied and 20% of the respondent are partially agree that they are satisfied.

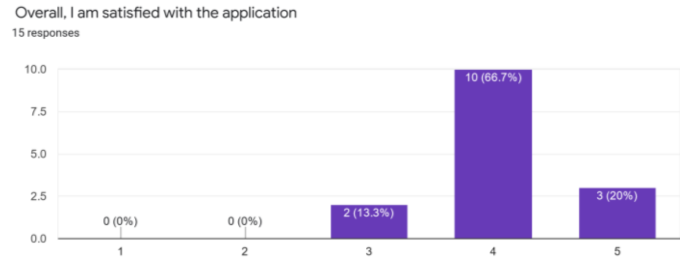

Fig. 17. Feedback on users' satisfaction using AR

C. *User Acceptance Testing*

This section discusses the user acceptance testing through the black box testing. The back box testing conducted without informs the participants. The black box carried out when the participant using the application by observing the participant actions. The expected result and actual result performed by the participant are compared in the Table 1. There are nine expected action that to be taken by the participants and every successful action will be tick (/) and cross (X) for action that has failed to perform by the respondent.

Based on Table 1, all the respondents had successfully used the AR user manual for printer configuration. All the players able to navigate in the application correctly by tapping on the buttons. The action printer information not achieve by two respondents as they skip the printer information and directly to printer configuration. All the respondents have achieved the expected result on printer configuration, scan marker, view instruction and follow instruction. One respondent not aware of the color instruction which changes from red to yellow as the component near to the correct location. One respondent did not tap on the button to return to main page and directly close the application.

VI. CONCLUSION AND SUGGESSTION

As conclusion, this research is successfully implementing the accurate positioning method to help the users to interact with the virtual component while performing printer configuration tasks within AR user manul application. However, this project still can be improved, for example, there are many comments and suggestions received from respondents after evaluation phase. Some future works are suggested to improve this project. Firstly, to include more type of printer model into this project. Apart from printer model, machines and vehicle that require user manual also can be added for configuration in the project. The application can be used for many configurations not restricted for only printer [20]. Next, the positioning information provided in the screen can be enhanced by adding graphical elements in real world space to show which direction to move a component to accurately placed on the correct placement. This suggestion may provide more clearly instructions for the users.

TABLE 1 USER ACCEPTANCE TESTING TABLE

No	Action	Expected Result	Actual result by respondents									
			1	2	3	4	5	6	7	8	9	10
1	Click button	User tap on the buttons	/	/	/	/	/	/	/	/	/	/
2	Printer Information	User reads printer information	/	/	/	X	/	/	X	/	/	/
3	Printer configuration	User select required type of configuration	/	/	/	/	/	/	/	/	/	/
4	Scan Marker	User hover the device camera to the marker	/	/	/	/	/	/	/	/	/	/
5	View Instruction	User read the instruction on the screen	/	/	/	/	/	/	/	/	/	/
6	Follow instruction	User follow the instructions on the screen	/	/	/	/	/	/	/	/	/	/
7	Colour instruction	User use the color changes to put the component correctly	/	/	/	/	/	/	/	/	X	/
8	Complete instruction	User complete all the steps	/	/	/	/	X	X	/	/	/	/
9	Go to main page	The user taps the return to main menu	/	/	/	/	/	/	/	/	/	x

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REFERENCES

[1] R. T. Azuma. (1997). A Survey of Augmented Reality. *Presence: Teleoperators and Virtual Environments*, 6(4), 355-385.

[2] R. Adams, D. Klowden, and B. Hannaford. (2001). Virtual Training for a Manual Assembly Task. *The Electronic Journal of Haptics Research*, 545-1143.

[3] User Guide. (13 July, 2021). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/User_guide.

[4] R. D. Amicis, A. Ceruti, D. Francia, L. Frizziero, and B. Simoes. (2018). Augmented Reality for Virtual User Manual. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 689-697.

[5] S. Baloch, S. Qadeer, and K. Memon. (2018). Augmented Reality, a Tool to Enhance Conceptual. *International Journal of Electrical Engineering & Emerging Technology*, 41-48.

[6] J. Carmigniani, and B. Furht. (2011). *Augmented Reality: An Overview*. New York: Springer.

[7] E. S. Goh, M. S. Sunar, A. W. Ismail, and R. Andias. (2018). An Inertial Device-based User Interaction with Occlusion-free Object Handling in a Handheld Augmented Reality. *International Journal of Integrated Engineering*, 10(6), 159-168

[8] E. S. Goh, M. S. Sunar, and A. W. Ismail. (2020). Device-based Manipulation Technique with Separated Control Structures for 3D Object Translation and Rotation in Handheld Mobile AR.

International Journal of Human-Computer Studies, 2020(141), https://doi.org/10.1016/j.ijhcs.2020.102433.

[9] Z. Oufqir, A. E. Abderrahmani, and S. Khalid. (2019). Important Method for Detecting and Tracking Based on Color. *International Journal of Engineering and Advanced Technology (IJEAT),* 8(5), 688-692.

[10] H. López, A. Navarro, and J. Relaño. (2010). An Analysis of Augmented Reality Systems. *2010 Fifth International Multi-conference on Computing in the Global Information Technology*, 245-250.

[11] J. P. Lima, F. P. Simoes, L. S. Figueiredo, and J. Kelner. (2010). Model Based Markerless 3D Tracking applied to Augmented Reality. *SBC Journal on 3D Interactive Systems.* https://doi.org/10.5753/jis.2010.560.

[12] D. Wagner, and D. Schmalstieg. (2006). Handheld Augmented Reality Displays. *IEEE VR 2006 Workshop on Emerging Display Technologies,* 35-36.

[13] J.M. Kruger, and D. Bodemer. (2020). Different Types of Interaction with Augmented Reality Learning Material. *Conference: 6th International 64 Conference of the Immersive Learning Research Network (iLRN 2020),* 78-85

[14] M.N. Billinghurst, and A. Henrysson. (2006). Research Directions in Handheld AR. *The International Journal of Virtual Reality*, 51-58.

[15] J. Choi, H. Park, J. Park, and J-I. Park. (2011). Bare-Hand-Based Augmented Reality Interface on Mobile Phone. *IEEE International Symposium on Mixed and Augmented Reality 2011 Science and Technology Proceedings,* 26-29.

[16] S. A. Chowdhury, H. Arshad, B. Parhizkar, and W. K. Obeidy. (2013). Handheld Augmented Reality Interaction Technique. *IVIC 2013: Advances in Visual Informatics,* 418-426.

[17] ZQ300 Series User Guide. (2019). Lincolnshire: Zebra Technologies Corporation.

[18] V. P. Thomas, S. C. Delphine, M. H. Patricia, and Angèle Gayet-Ageron. (2015). *Sample Size for Pre-tests of Questionnaires. Quality of Life Research,* 24(1), 147-151.

[19] H. Shu (2014). Pretesting. *A. C. Michalos (Eds.). Encyclopedia of Quality of Life and Well-Being Research,* 5048-5052.

[20] E. S.Goh, M. S. Sunar, and A. W. Ismail. (2019). 3D Object Manipulation Techniques in Handheld Mobile Augmented Reality Interface: A Review. *IEEE Access,* 2019(99): 1-1. https://doi.org/10.1109/ACCESS.2019.2906394.