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Developed Jepara 3D Augmented Reality Furniture Catalog Application Based on Android

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Abstract: Jepara, a regency in Central Java, Indonesia, stands as a prominent hub for the wooden furniture industry, boasting a reputation that extends globally. Traditional marketing approaches, particularly the use of physical catalogs, encounter notable challenges in this digital era. This study identifies the limitations of conventional print catalogs in generating consumer interest and facilitating access to store information in Jepara's teak furniture market. To address these challenges, we introduce an innovative solution employing Augmented Reality (AR) technology. Utilizing the waterfall development methodology, this research develops an AR application compatible with Android devices. This application transforms the furniture shopping experience by presenting 3D visualizations of products, complete with detailed dimensions, thus enabling consumers to gauge the actual size of the items. Furthermore, the application curates a list of high-rated furniture stores in Jepara, offering comprehensive store information. This integration of AR technology not only enriches the consumer experience but also adds an interactive dimension to the furniture purchasing process.

Keywords: Furniture Industry; Marketing Innovation; Augmented Reality; Waterfall Methodology; Android Applications.

1. Introduction

The use of catalogs is an effective tool in marketing strategies for introducing products to consumers [1]. Unlike other types of publishing media such as brochures, catalogs offer more specific focus and segmentation, targeting a particular audience [2]. Catalogs typically have a longer lifespan compared to brochures and present a richer and more diverse content. In Jepara, a renowned carving city in Central Java, Indonesia, furniture catalogs are usually distributed in print, aiming to provide an overview of furniture products to consumers. Known as the largest wooden furniture industry hub in Indonesia and often referred to as "The World Carving Center," Jepara produces high-quality furniture items that are popular domestically and are exported to countries like the USA, Japan, and Europe [3].

However, a survey conducted by researchers indicates that many consumers view the use of printed catalogs as a conventional and less innovative promotional tool, affecting their interest in purchasing furniture and making it challenging to find information about furniture stores [4]. In a competitive market environment, it is crucial for Jepara furniture industry to seek new strategies to stay competitive. This research aims to develop an innovative solution using Android-based Augmented Reality (AR) technology, allowing consumers to view furniture products in three dimensions using catalog images or markers. AR combines the physical and virtual worlds, creating an experience where consumers can view furniture products in a more detailed three-dimensional format [5]. Stephen Cawood and Mark Fiala describe AR as an effective way to explore 3D objects and data, merging elements of virtual reality and the real world so that 2D or 3D virtual objects appear as an integral part of the real world [6]. According to Haller, Billinghurst, and Thomas (2007), AR research aims to develop technology that integrates computer-generated digital content with the real world in real-time, differing from Virtual Reality (VR) which completely isolates users in a fabricated environment. AR allows users to see three-dimensional virtual objects displayed in the real world around them [7].

A comparative study between Android and iOS users by Moon Technolabs Pvt Ltd in 2017 showed that Android dominates the market with an 87% share, while iOS has a 12% share. Android is more popular in developing countries,

particularly in Asia and Africa, while iOS dominates in developed countries such as the USA, Australia, and Europe. These differences are influenced by cultural and socio-economic factors in different geographical regions [8]. In its evolution, AR has extended beyond its visual aspect and can now be applied to all human senses, including hearing, smell, and touch. Its application is not limited to sectors like healthcare, military, and manufacturing but also extends to the business world, including the furniture industry. One such application is using AR to present three-dimensional furniture catalogs to consumers [9].

2. Research Method

2.1. Marker-Based Tracking:

The concept of marker-based tracking in Augmented Reality technology, as explained involves recognizing and identifying markers with specific patterns, typically square illustrations on a bold black and white background [7][8]. These markers are used to overlay virtual 3D objects onto the real physical environment. The computer uses information from these markers, such as position and orientation, to create a virtual 3D world in the physical environment using a central point (0,0,0) and three axes: X, Y, and Z. This marker-based tracking technique has been developed since the 1980s and has been utilized in the context of augmented reality since the early 1990s [9].

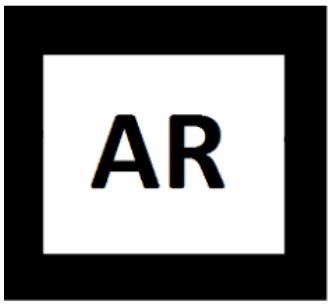


Figure 1. Marker-Based Tracking

2.2. Waterfall Method

The development methodology employed in this application is the waterfall method. This approach implements a structured and sequential process, beginning from the planning stage to management. The process unfolds in stages, including six phases: Requirements Gathering, System Design, Development, Testing, Deployment, and Maintenance and Support [10]. These stages are illustrated in Figure 2.

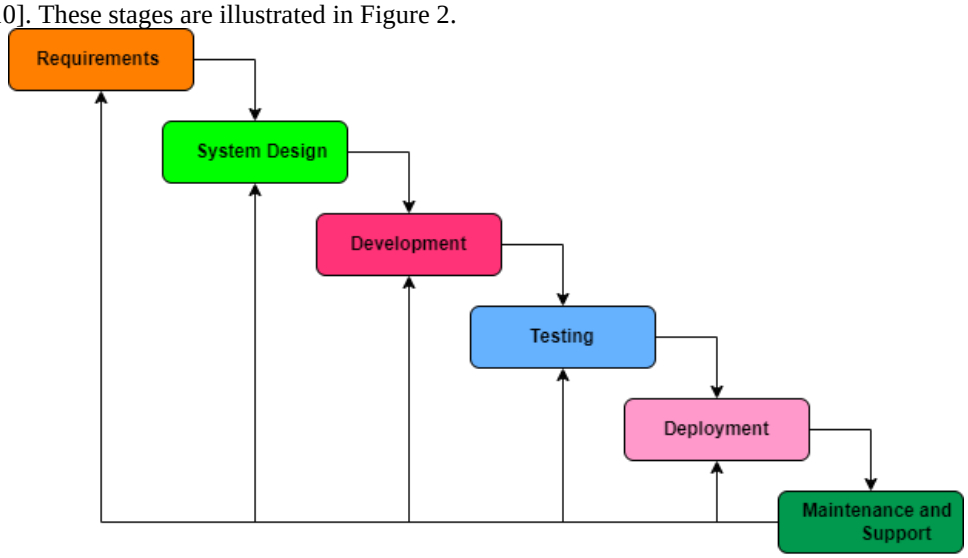


Figure 2. Waterfall Method

In the development of the Augmented Reality furniture catalog application, the six stages are as follows:

1) Requirements Gathering
   This first stage involves a thorough analysis of the issues faced by consumers and furniture business owners in Jepara. The primary focus is on identifying key problems and needs. The findings from this analysis will lay the foundation for further design.

2) System Design
After gathering requirements, the next step is comprehensive system design. This includes planning the structure of the AR application, designing the app pages, and the appearance of furniture products in a 3D format. Plans for developing 3D models using SketchUp software also take place at this stage.
3) Development
During the development stage, the 3D models designed in the previous stage are created using SketchUp software. Subsequently, these models are integrated into the Unity software, and Augmented Reality (AR) technology is implemented using the Vuforia module.
4) Testing
This stage focuses on application testing. Two primary testing methods are employed: functional testing and non-functional testing. Functional testing ensures the application works as expected and required. Non-functional testing includes compatibility testing with various Android operating systems to determine minimum specifications and direct testing on Android devices.
5) Deployment
After successful testing, the AR application is compiled and integrated into smartphone devices. The application is then ready for deployment to end-users.
6) Maintenance and Support
The final stage involves maintenance and support. This includes managing the application post-launch, troubleshooting, and making necessary repairs.

The above-described Waterfall approach follows a linear stage sequence, where each stage is completed before moving to the next. This provides a structured and detailed framework for the efficient development of the furniture AR application.

2.3. Research Framework

Based on Figure 3, the problem in this research is the lack of efficiency in using physical furniture catalogs. Potential furniture buyers must visit stores in person to view two-dimensional printed catalogs, which is considered inefficient due to time consumption and may not align with the preferences of potential buyers. The proposed solution in this research is the development of an Augmented Reality (AR) furniture catalog application accessible via Android devices. Data such as models and sizes of furniture products will be collected and then displayed in a 3D format in the AR application. The result of this system is an AR application that enables potential buyers to view furniture products in a three-dimensional display on their Android smartphones. This application aims to improve efficiency by eliminating the need for physical store visits and making it easier for potential buyers to find the best furniture stores with complete information. The research framework can be seen in Figure 3.

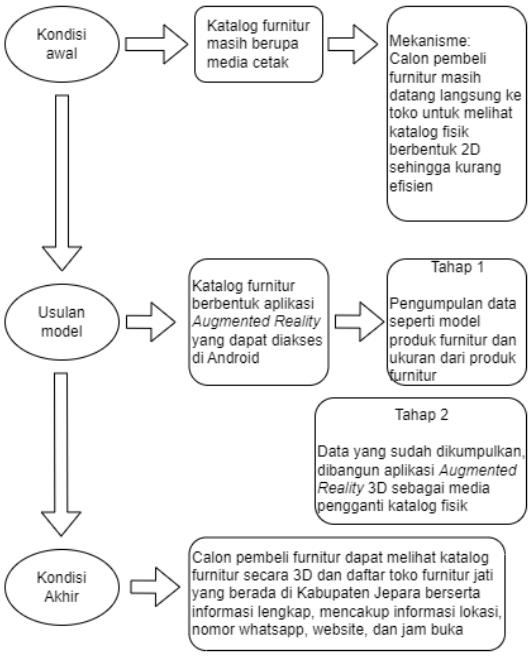


Figure 3. Research Framework

2.4. Augmented Reality Application Workflow

The developed Augmented Reality furniture catalog system involves collecting data from customers in the form of scanning markers using the ARFurnitur app. Next, the app sends a marker request to the Vuforia database and validates the marker. If the marker matches, the app displays the 3D furniture product object to the customer. This process is depicted in Figure 4.

Figure 4. Augmented Reality Application Workflow.

3. Result and Discussion

3.1 Results

The outcome of the application implementation is a crucial phase in this project, encompassing the realization of the initial design to meet the established goals and requirements, and is the result of pre-evaluation testing [11].

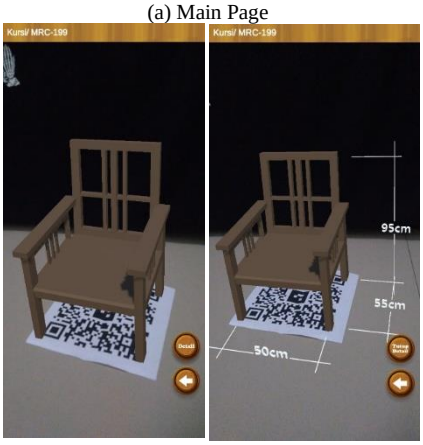
3.1.1 Application Interface

The main page of the application displays a number of furniture product images. This page also features three main buttons: "Help," "AR Furniture," and "Info." The appearance of the main page is shown in Figure 5.a.

(a) Main Page

(b) Furniture Type Page

(c) Product Page

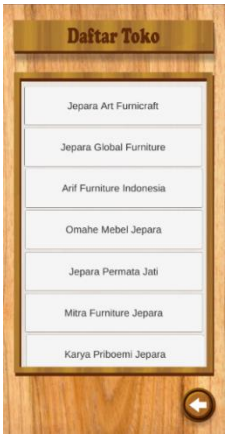


(d) AR Product Page

(e) Help Page

(f) Info Page

(g) About Application Page



(h) Store List Page

(i) Store Information Page

Figure 5. App View

The furniture type page shows various types of furniture available in the application, such as chairs, buffets, wardrobes, beds, etc. These furniture types are initialized as buttons. This page also includes a button to print markers and a button to return to the main page. The appearance of the furniture type page is shown in Figure 5.b. The product page displays various furniture products complete with images and types of products. These products can be accessed through a button to switch to the AR Product page. This page also has a back button to return to the furniture type page. The appearance of the product page is shown in Figure 5.c. The AR product page displays the selected furniture product in augmented reality 3D form. This page shows the 3D object along with its actual dimensions, such as length, width, and height. The page also has a back button to return to the product page. The appearance of the AR product page and its size details are shown in Figure 5.d. The AR Furniture application help page provides instructions on how to use the application. These instructions are intended to assist users who are still confused about how the application works. The instructions are presented in a vertically scrollable step-by-step format. The help page also has a back button to return to the main page. The appearance of the help page is shown in Figure 5.e. The information page of this application displays buttons that direct users to the store list page, the about page of the application, and a back button to the main page. The appearance of the info page is shown in Figure 5.f. The "About Application" page of this application displays information about the application, such as its functions, the minimum Android version specifications required, and the name of the application developer. This page also has a back button to the info page. The appearance of the "About Application" page is shown in Figure 5.g. The store list page displays a list of high-rated furniture stores in Jepara. This page also has a back button to the information page. The appearance of the store list page is shown in Figure 5.h. The store information page displays important information about a store, such as address, phone/WhatsApp number, website, and operational hours. This page also has buttons for each piece of information that can be clicked to open the related links. These buttons include Google Maps, WhatsApp, Website, and a back button to the store list page. The appearance of the store information page is shown in Figure 5.i.

3.1.2 Black Box Testing

Black box testing is utilized to assess the functionality of the program and detect execution errors or comprehensive system functions [12]. Each test case involves providing input to observe the application's output and ensuring that the generated output aligns with the application developers' expectations. This testing also aims to identify potential errors in the application so that corrections can be made promptly if any errors are found during testing. Software testing based on functional specifications is a process intended to verify whether the software's functionality, inputs, and outputs are in accordance with the defined specifications. It does not necessarily involve evaluating the program's design and code [13]. Table 1 shows the results of black box testing on the "AR Furniture" application.

Table 1. Black Box Testing Results

No.	Menu	Test Cases and Results	Conclusion
1	AR Furniture	When the AR Furniture button is clicked, a page of furniture types should be displayed	Successful
2	Help	When the help button is clicked, instructions for use should appear	Successful
3	Back (in help menu)	When the back button in the help menu is clicked, the user should return to the main menu	Successful
4	Info	When the info button is clicked, an info page containing a list of stores and information about the app should be displayed	Successful
5	Back (in info menu)	When the back button in the info menu is clicked, the user should return to the main menu	Successful

6	Print Markers	When the print marker button is clicked, the user should be directed to the Google Drive page to display the marker	Successful
7	Back (in furniture type menu)	When the back button in the furniture type menu is clicked, the user should return to the main menu	Successful
8	Types of Furniture	When a furniture type (chair, sideboard, cupboard, etc.) is clicked, the selected furniture product page should be displayed	Successful
9	Back (in furniture product menu)	When the back button in the furniture product menu is clicked, the user should return to the furniture category menu	Successful
10	AR products	When the selected product is clicked, the user should enter the AR Scene	Successful
11	Detail	When the details button is clicked, the product size in 3D should be displayed	Successful
12	Close Details	When the close details button is clicked, the dimensions on the 3D product should be removed	Successful
13	Back (in AR Scene menu)	When the back button in the AR Scene menu is clicked, the user should return to the product's AR menu	Successful
14	About the app	When the about app button is clicked, information about the app should be displayed	Successful
15	Back (in the about app menu)	When the back button in the app's about menu is clicked, the user should return to the info menu	Successful
16	Store list	When the shop list button is clicked, a list of several furniture shops in Jepara should be displayed	Successful
17	Back (in store list menu)	When the back button in the store list menu is clicked, the user should return to the info menu	Successful
18	Store information	When the shop name is clicked, the shop information containing the shop address, WhatsApp number, website and operating hours should be displayed	Successful
19	Maps	When the maps button is clicked, the user should be directed to the Google Maps application according to the selected store location	Successful
20	WhatsApp	When the WhatsApp button is clicked, the user should be directed to the WhatsApp application according to the store's WhatsApp number	Successful
21	Website	When the website button is clicked, the user should be directed to the browser and automatically open a link from the shop website	Successful
22	Back (in store information menu)	When the back button in the store information menu is clicked, the user should return to the store list menu	Successful

3.1.3 Compatibility Testing

Compatibility testing is conducted to determine the minimum requirements that devices must meet to run the application. In this test, various smartphones with different operating systems were tested, and the results are documented in Table 2. The compatibility testing results in Table 2 indicate that the AR furniture application requires Android OS version 8.1 (Oreo) or newer to operate properly. On the Oreo operating system, all application features function without issues. However, on older versions like Android OS 7.0 (Nougat), there were difficulties in displaying 3D objects.

Table 2. Compatibility Testing Results

Operating system	Test results
Android 11	Runs well
Android 10	Runs well
Android 9.0 (Pie)	Runs well
Android 8.1 (Oreo)	Runs well
Android 7.0 (Nougat)	Doesn't appear 3D

3.1.4 Testing on Android Devices

Device testing is the process of ensuring that an application works well on various devices that users may utilize. This testing is done by testing the application on different types of devices with varying specifications [14]. The goal is to find and fix any issues or limitations that may occur with the application on certain devices. A list of Android devices used to test the AR Furniture application is presented in Table 3.

Table 3. Testing on Android Devices

No.	Device Brand	Specification	Results	
			Information	Status
1	Xiaomi Redmi Note 10S	Android 11 operating system, RAM capacity of 8 gigabytes, rear camera with 64 megapixel resolution, and screen resolution reaching 1080 x 2400 pixels.	Switching between pages of the AR Furniture application takes place smoothly. Moving from the main page to the Furniture Types, help and info menu takes 1 second, while moving to the AR Scene page and store list page takes 2 seconds.	Succeed
2	Realme C1	Android operating system version 9, RAM with a capacity of 2 gigabytes, rear camera with a resolution of 13 megapixels, and screen resolution reaching 720 x 1520 pixels.	Switching between pages of the AR Furniture application takes place smoothly. Moving from the main page to the Furniture Types, help and info menu took less than 2 seconds, while moving to the AR Scene page and store list page took 3 seconds.	Succeed
3	Xiaomi Pocophone F1	Android operating system version 10, 6 gigabytes of RAM, rear camera with 12 megapixel resolution, and screen resolution of 1080 x 2246 pixels.	Switching between pages of the AR Furniture application takes place smoothly. Moving from the main page to the Furniture Types, help and info menu took less than 2 seconds, while moving to the AR Scene page and store list page took 1 second.	Succeed

3.2 Discussion

The study demonstrates that the three-dimensional augmented reality application in Jepara wooden furniture catalog, developed using the waterfall method, brings numerous benefits in supporting this research. This application simplifies the process for potential furniture buyers to observe furniture products in a 3D format, eliminating the need for physical store visits. Additionally, it assists consumers in easily locating furniture stores. During the application development process, Unity software was used for creating the application, while Visual Studio Code served as the text editor. The programming language employed was C#, and Vuforia was used for storing marker image data. The application features several main menus, such as the AR Scan to display furniture products in three dimensions with size details, an information menu containing comprehensive data about renowned furniture stores in Jepara, and a guide menu providing instructions on how to use the application. The implementation of augmented reality successfully offers a solution for consumers who wish to view furniture products directly without the need for physical visits to furniture stores. This discussion highlights the practical implications of augmented reality in enhancing the furniture shopping experience, emphasizing the technological advancements and user-friendly interface of the application. The use of modern programming tools and languages further underscores the application's robustness and versatility. The study's findings could pave the way for more widespread adoption of AR technology in various retail sectors, especially in areas where physical store visits are challenging or inconvenient. The successful application of AR in this context demonstrates its potential as a versatile tool in modern marketing and customer engagement strategies.

4. Related Work

This study encompasses an array of previous research related to the application of Augmented Reality (AR) technology in various contexts. As a comparative analysis, the study by [15] attempts to implement AR in furniture catalogs using marker-based tracking and features that assist prospective consumers in making more detailed product choices. Another research [16] investigates the use of AR in furniture catalog promotion, employing marker-based tracking and the steps of the Multimedia Development Life Cycle. Further, [17] explores the application of AR in a catalog for screen-printed clothing sales, using marker-based tracking and repeated marker detection to display shirt designs. The study by [18] integrates marker techniques for visualizing house models with AR, using multi-markers to display 3D objects on house models, along with various additional features. In a different approach, [19] focuses on applying AR in house sales catalogs using a markerless technique, where markers are obtained from any image or surface containing text or logos. This allows users to view house visuals in 3D and includes features such as zooming in, zooming out, and rotation without additional equipment. This research presents a diverse array of approaches in the application of AR, demonstrating the various benefits that can be achieved in different research contexts. The studies showcase the versatility of AR in enhancing user experience and providing innovative solutions for product visualization and interaction. These works collectively indicate the growing trend of utilizing AR technology in commercial and educational domains, offering insights into its potential for future applications.

5. Conclusion

In conclusion, this research affirms that the implementation of a three-dimensional augmented reality application in the Jepara wooden furniture catalog using the waterfall method brings significant benefits. The application facilitates prospective buyers in viewing furniture products in a 3D format without the necessity of visiting physical stores and assists in easier location of store premises. It features main menus such as AR Scan, an information menu, and a guide menu. However, the use of this application is contingent on the device specifications and ARCore support. While this research has been successful, there is potential for further development by adding features such as an in-app product ordering system, increasing the number of 3D objects, improving the user interface, and enhancing the realism of the three-dimensional objects. Therefore, this study provides a strong foundation for further development in optimizing the Android-based Jepara furniture catalog augmented reality application. This research not only contributes to the field of AR applications in retail but also sets a precedent for future technological advancements in enhancing consumer experience in various industries.

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