Augmented Reality Technologies for Interior Design Planning using a Simultaneous Localization and Mapping Method

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Abstract. Planning the placement of furniture in a room is an important planning process, with proper planning, the placement of furniture can be more efficient in the use of space, as well as from an aesthetic point of view. During this time the process can be done by using a sketch or other manual method. In this research, we use augmented reality technology to plan furniture placement in a room. We use the Markerless technique in the implementation of this AR system, and use the Simultaneous Localization and Mapping (SLAM) technique to determine the geospatial point where the furniture will be the desired layout. The results of this application found that good minimum distance in detecting SLAM on the ground is 60 cm and can only be seen up to a maximum position of 45 ° from the Z axis of the camera's initial position when tracking. This application runs on the Android mobile platform.

1. Introduction

Augmented Reality (AR) is a technology that aims to combine the real world with the virtual world. Development of Augmented Reality (AR) conducted by developers allows this technology to be applied in various fields, such as the world of entertainment, business, education, and so on. This is caused by the features presented by Augmented Reality where this technology is able to provide visual appearance in the form of interesting 2D and 3D objects [1].

Interior design is a trend that is in great demand to beautify the appearance of the room. The difficulty in changing the layout or adding to the collection of home furniture is to arrange it to look efficient, the room is not too narrow and so that the order of home furniture looks beautiful to look at. To change the layout so that it exactly requires repetitive settings so that it just wastes energy and time. Augmented Reality technology allows the work to be easy and efficient, so it will not take up the energy and time to display the 3D objects.

Today the use of smart phones is one of the most important needs for the community. Smart phones that have many functions can facilitate users in everyday life. In this research, the author will build a system or application of Augmented Reality in real-time and mobile-based and without using markers or called markerless augmented reality where it can facilitate a person to design the interior of the room more effectively and efficiently without having to experience difficulties in managing it manual and also use markers as markers to bring up 3D objects[2]. In this study the authors built an Android-based one.

Interior design arrangement of a room requires a model that is drawn manually or using design software is considered less effective and efficient because it requires a long time in its creation and
modelling and only presents a 2D-shaped object model that lacks visualization of the reality. Therefore, an application is needed by using Android-based Augmented Reality (AR) technology that can help users in designing a room to their liking more easily and can be done in real-time. Markerless Augmented Reality technology can make the implementation of Augmented Reality much more efficient, practical, attractive, and can be used anywhere, anytime without printing markers. 

Research on Augmented Reality has been widely implemented in various fields. Such as education, medicine, marketing, culture, business and more. In general, Augmented Reality is implemented as a medium of recognition or learning. So that makes learning more interesting and interactive. Some of previous research: Interior Design in Augmented Reality Environment. This research makes Augmented Reality to display virtual furniture so that it becomes a learning media for interior design. Using Tangible AR and ARToolkit which still use markers and multi markers. [3]. Design and Implementation of Interior Design Applications Based on Augmented Reality Technology. This study uses Adobe Flex and ARToolkit Marker Generators by using markers to display visuals in 3D in accordance with the design [4]. Markerless Augmented Reality Android App For Interior Decoration. Make an Augmented Reality application based on markerless to design the interior, where each novice user can easily decorate his house. This application is based on Android and uses Metaio SDK and ARToolkit [5]. Setting Home Furniture Layout With Augmented Reality. The purpose of this study was to examine the state-of-the-art of technology, systems, and applications of augmented reality and also the application of Augmented Reality technology using markers to help arrange the layout of home furniture [1]. Visualization of Virtual House Model on Property Brochure Using Augmented Technology, which use augmented reality technologies to present 3d property brochure [6] with a finger interaction [7] has become its previous researches.

2. Methodology

2.1. General Architecture

The following is an explanation of the stages in the general architecture:

2.1.1. Input

![Figure 1. General Architecture](image)
The user runs the Augmented Reality Decor AR application found on the smartphone. The user presses the Start button to start the application and will display the AR Camera display. The user selects the 3D object that he wants to display so that the display will appear selecting the object of the household furniture that will be displayed.

2.1.2. Process

The system identifies flat surfaces on the floor with AR Tracking SLAM to determine angles and track positions to display 3D objects. Previously 3D objects were created via 3D Studio Max, then exported to OBJ or FBX format then exported via Unity 3D. Then the system will adjust according to the selected 3D object. Then the system will render 3D objects. And displays 3D objects of household furniture to the smartphone screen. 3D objects will be placed in the lower left of the smartphone screen. and can be changed by shifting the object by sliding it by using a finger and can also enlarge and rotate the 3D object. Users can also add more than one desired object so that they can organize and design the layout of home furniture in the space.

2.1.3. Output

The resulting output is a 3D object that adapts to the floor surface. Users can also change their location by sliding the object by sliding it by using a finger and can also zoom in and rotate the 3D object. Users can also add more than one desired object so that they can organize and design the layout of home furniture in the room.

2.2. Markerless Tracking Method

Marker-less tracking is an Augmented Reality method where the tracking process is no longer only using markers as detection targets. With this method, the Augmented Reality process is no longer limited to markers, but visual images, 3D objects, GPS or faces that can be used as detection targets.

The difference between marker-based and marker-less is that the process of tracking the camera position and camera orientation is calculated with the markers that have been set. Whereas marker-less calculates the position and orientation of the camera and the real world without any specific provisions, using only natural features such as edges, corners, lines or 3D models. The marker-less method used in this study is the image tracking method where visual images are used as targets for the Augmented Reality application built. Examples of image tracking Augmented Reality applications can be seen in Figure 2.4. Can be seen after the teapot object appears above the marker pictured after tracking by the system.

![Figure 2. Markerless Image Tracking](image-url)

2.3. Activity Diagram
Activity diagrams or activity diagrams are diagrams that illustrate the various flow of activities in the system that are being designed, how each system flow begins, decisions that may occur, and how they end. Activity diagrams can also describe parallel processes that might occur in several executions. Start Activity diagrams explain the application system activity in running the camera to start the tracking process. The Start activity diagram can be seen in figure 3.

3. Result and discussion

3.1. Implementation
DecorAR application implementation is done by implementing the Wikitude SDK library and Simultaneous Localization and Mapping (SLAM) library into applications by using the developing Unity3D tool to build applications.
This research has a choice of 10 3D objects of furniture to be displayed, namely 3 cabinets, 2 tables, 2 chairs, 2 decorative lights, and 1 flower vase. Views that will be designed in this application, namely the main menu display page, Object menu page, Control Object page, Gallery menu page and About menu page.

![Figure 4. Main Menu Page Display](image)

When starting to operate this application it will immediately show the main page. In the main page view there is a DecorAR application logo and 4 menus. The four menus are Start, Gallery, About, and Exit. Display of the main menu of the application can be seen in Figure 4.

![Figure 5. AR Camera Page View](image)

In the Augmented Reality menu, there are 5 buttons that can be selected and each has its own function. Augmented Reality menu display on the application can be seen in Figure 5.

**Navigation Description:**
- **Main Menu**: Works to return to the initial menu.
- **Capture**: Functioning to take pictures from 3D object designs displayed.
- **Place Object**: Function to display a menu for selecting objects.
- **Light button**: Function to make the condition of the room glow or not glow.
- **Clear**: Works to delete all 3D objects that have been raised on the AR Camera screen.

![Figure 6. Object Menu Display page](image)
The function of this page is this is a page where users can select 3D objects that will be displayed on the AR Camera menu page. As in Figure 6, on this page there is a 3D object button that is ready to be selected to appear on AR Camera

![Figure 7. Control Object Display page](image)

This page contains control of 3D objects by changing positions, enlarging and rotating 3D objects of home furnishings so that they can design space more easily as desired. Users can use the available bar to rotate objects and use both fingers to zoom in and out on objects. The appearance of the Control Object page in the application can be seen in Figure 7.

3.2. Markerless testing

3.2.1. Testing slam detection

Markerless testing is tested by conducting SLAM testing to prove that users can use markerless methods to display 3D objects of household furniture. This test is carried out on different aspects that will be used to display 10 3D objects of home furnishings. The test is done by opening the DecorAR application, then activating AR Camera by pressing the Start button found on the application Main Menu display and pointing it to the desired place, then selecting the object of the household furniture that you want to display.

![Figure 8. SLAM testing](image)

In Figure 8 is a user-defined location to serve as a ground to place the 3D object. There is a grid in the form of a grid that is a checkerboard as a marker for ground detection. And the other figure in Figure 8, the object of household furniture that has been selected has been successfully raised. If the user exits the AR Camera page, the predetermined ground that is laying the 3D object will be removed from the system so that SLAM will detect it from the beginning again.

3.2.2. Testing slam detection based on distance

This experiment to find out from what distance SLAM is able to detect ground. This test is done using one 3D object. In the distance test, the closer the distance between the camera and the ground, the SLAM will not detect the ground properly so that 3D objects that appear will easily disappear because the ground position cannot be captured properly. There is an indicator on the grid contained in the ground that makes the user know if SLAM is functioning properly or not.
Figure 9. SLAM indicator for ground distance

In Figure 9 shows a green line indicator at the bottom of the AR Camera page which indicates that SLAM detects the ground properly. And the other Figure 9 shows a red line indicator at the bottom of the AR Camera page which indicates that SLAM does not detect the ground properly. The results of the test distance can be seen in Table 1.

Table 1. SLAM distance test results to detect ground.

| No | Distance | Ground | Trial Display (Object) | Result |
|----|----------|--------|------------------------|--------|
| 1  | 10 cm    | Not detect | ![Image](image1) | Object does not appear |
| 2  | 50 cm    | detect   | ![Image](image2)      | Objects appear poorly so that objects can disappear easily because SLAM does not detect ground |
| 3  | 90 cm    | detect   | ![Image](image3)      | Object appears well |
| 4  | 120 cm   | detect   | ![Image](image4)      | Object appears well |
5 150 cm detect Objects do not appear properly

The test results in table 1. give the results of the SLAM function to detect ground as a good object placement done at a minimum distance of 60 cm so that SLAM can work properly and a maximum distance that is good for using SLAM function is 120 cm.

3.2.3. Testing slam detection based on angle
Position detection testing is performed to determine which position SLAM can detect the ground by the system. The test was carried out using 1 3D object of household furniture by shifting the AR Camera towards a different one which is to the left or right based on the Z axis by using an angle to shift the position from the initial position. Position testing results can be seen in Table 2.

| No | Posisi  | Ground    | Tampilan Uji Coba (Objek) | Hasil Pengujian         |
|----|---------|-----------|---------------------------|-------------------------|
| 1  | 0° from the starting position | detect | ![Image](image1.png) | Object appears well |
| 2  | 15° from the starting position | detect | ![Image](image2.png) | Object appears well |
| 3  | 30° from the starting position | detect | ![Image](image3.png) | Object appears well |
| 4  | 45° from the starting position | detect | ![Image](image4.png) | Object appears well |
The results in table 2, show the testing of the SLAM function that can be done by sliding the AR Camera to the right or left of the Z axis to detect the ground and the object that has been displayed only up to a maximum of 45° from the initial position of the AR Camera. If the AR Camera is shifted above 45° then the object or ground is not detected again so the object and ground disappear. However, if AR Camera is returned at the initial position then SLAM will detect the ground that has been locked during the tracking phase so that SLAM can reappear the ground and the object that has been displayed before.

4. Conclusion
After carrying out the implementation phase and testing the system, then obtained some conclusions found in this study, namely:

- The DecorAR application is able to display the AR Camera system and display 3D objects of home furniture.
- The DecorAR application is capable of displaying multiple 3D objects.
- A good minimum distance in detecting SLAM on the ground is 60 cm and can only be seen up to a maximum position of 45° from the Z axis of the camera's initial position when tracking.
- More interactive applications with objects that can be set by the user.

5. References
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