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Implementation of Augmented Reality in Foreign Languages (English - Arabic) Using the Marker-Based Tracking Method

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Abstract

Mastery of foreign languages, particularly English and Arabic, remains a challenge for Indonesian students due to limited exposure, low motivation, and the inadequacy of conventional learning media. This study aims to enhance students' interest and learning outcomes in English and Arabic through the development and implementation of a Marker-Based Augmented Reality (AR) learning application. The research employs a design and development methodology, integrating AR with marker tracking using Vuforia and Unity, and evaluates the application across key functional scenes, including vocabulary recognition, interactive 3D object projection, quizzes, and learning materials. The results indicate that the AR application significantly improves engagement, motivation, and comprehension, allowing students to experience contextualized learning in an interactive and flexible environment. Marker-Based Tracking ensures accurate real-time projection of virtual objects onto physical markers, supporting multi-modal language acquisition, including vocabulary, pronunciation, and contextual understanding. Furthermore, the application demonstrates practical usability, scalability, and adaptability for self-directed and blended learning, highlighting its potential as a complementary educational tool. These findings suggest that AR can serve as an effective innovation to address low interest and achievement in foreign language learning, providing a model for immersive and interactive pedagogical practices. However, limitations such as device dependency and short-term evaluation underscore the need for further research to examine long-term learning outcomes, wider population applicability, and integration with markerless AR technologies. Overall, the study contributes to the emerging field of AR-mediated language learning by offering both theoretical insights and practical guidance for educators and developers.

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1. Introduction

With today's technological advancements, humans can develop many positive tools in their respective fields. One such area is education. Mastery of foreign languages is crucial for students, especially English and Arabic. English is an international language, but Arabic is another widely spoken language worldwide. In Indonesia, the current problem is that Arabic is less popular, making it slightly more difficult to learn than English. Another reason for students' lack of interest in learning foreign languages is due to several factors: Arabic is rarely spoken in Indonesia (only by certain ethnic groups), difficulty understanding Arabic, current learning media deemed unsuitable for fostering student interest in learning English and Arabic, and limited time for learning English and Arabic (Amin, 2024; EF Education First, 2023).

The purpose of this study is to increase interest in learning English and Arabic by using technology-based learning media, namely Augmented Reality (AR). With interactive and fun learning methods and the use of gadgets, students are expected to grasp the material more quickly. Unlike conventional learning methods, where students simply listen to the teacher explain the material, this learning method allows students to directly experience the material through their gadgets, and they can also learn anywhere and anytime. English-Arabic language learning media uses Augmented Reality, a 3-dimensional technology that combines the physical world and the computer or digital world in real time (Azuma, 1997; Tsania Khoirunnisa et al., 2025). The development of Augmented Reality technology is guided by two main models: a method for tracking information from the physical world using specific techniques. Augmented Reality technology has three main pillars: as a tool for tracking all information related to real-world objects being processed; support from hardware and software for managing and processing information; and devices that support and can be used to support the use of digital information integrated into the real world (Wardahtul Mu'minah et al., 2025).

Augmented Reality is a term used to refer to a technology that combines the real world and the virtual world directly or in real time. This research will also utilize the Marker-Based Tracking method, a two-dimensional object marker with a pattern that is read through a webcam or camera connected to a computer. With augmented reality technology, users can view virtual objects projected onto the real world in an attractive 3D form, thereby preserving the English-Arabic language (Hafitria & Asrofi, 2023).

However, despite promising findings from several studies on AR for language learning, there remains a significant research gap: many existing works in the Indonesian context focus only on limited dimensions of Arabic learning, such as vocabulary (mufrodat) using marker-based AR. For example, research by Hafitria and Asrofi (2023) developed AR flashcards for Arabic vocabulary but did not address more complex language skills. Another study created 3D AR for speaking practice, but this has rarely been tested over a longer period or integrated with pedagogical models that promote grammar, listening, and interaction (Setiawan, 2019). A literature review also highlights persistent challenges such as limited infrastructure, lack of teacher training, and insufficient long-term empirical evaluation (Mu'minah et al., 2025). These gaps indicate that while AR has potential, its application in a holistic, scalable, and sustained way for Arabic (and even English) learning in Indonesia is underexplored—and this is precisely what makes the present study scientifically urgent.

Moreover, the need for intervention is underlined by measurable evidence of low proficiency and motivation. According to the EF English Proficiency Index 2023, Indonesia ranks 79th out of 113 countries, with a score of 473—below the global average of 502 (EF Education First, 2023). On the Arabic side, research points to very low learner engagement: for example, a study of madrasah ibtidaiyah students found that 64% of students report low interest in learning Arabic (Amin, 2024). In addition, analyses show that students' low motivation and weak Arabic learning achievement are strongly linked, and that traditional teaching methods and lack of engaging media contribute to this problem (Fadilah, 2024). Together, this evidence underscores the urgent need for an AR-based learning media that can reinvigorate students' interest, support diverse language skills, and ultimately improve learning outcomes in both English and Arabic.

2. Research Methodolgy

This research will involve a study of the application of augmented reality technology in foreign language learning (English and Arabic) using the marker-based tracking method at Forward Tutoring. The research methodology defines the procedures and steps required to achieve the design objectives. These steps are:

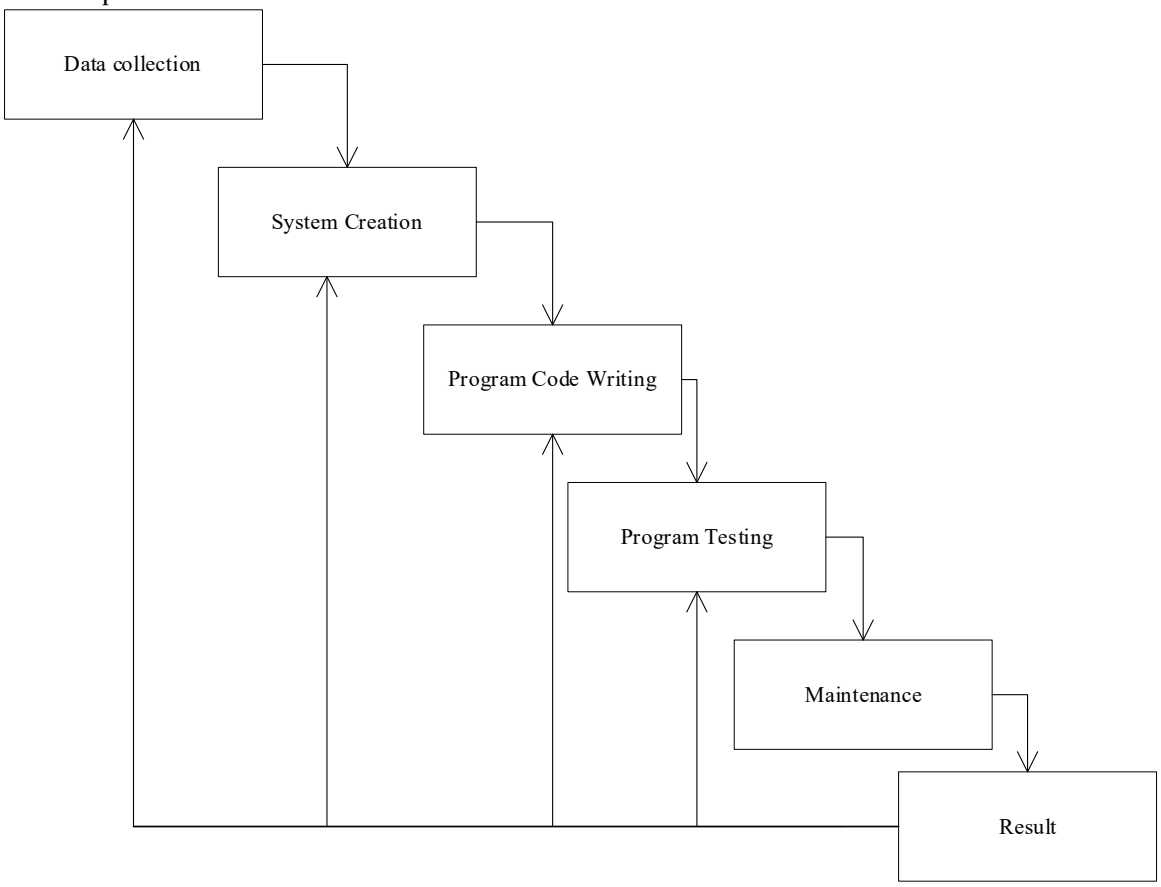

Figure 1. Waterfall Diagram

1. Needs Analysis

This analysis phase identifies the requirements for designing the application of augmented reality technology in foreign language learning (English and Arabic) using the marker-based tracking method at Forward Medan Tutoring.

2. Design

The design phases involved in creating the system and application to be designed by the author are:

a. Designing the system using UML (Unified Modeling Language).
b. Using Dreamweaver to design the application.
c. Using Visio to draw the system flowchart.

3. System Testing

After the designed system has been implemented into an application, the next phase is testing, encompassing specifications, design, and coding. In this study, system testing was conducted through black-box testing of all application functions. Black-box testing is a type of application or software testing that focuses on the functional requirements of the software.

4. System Implementation

To be understood by a computer or personal computer (PC), the design must be transformed into a form that can be understood by a computer or personal computer (PC), namely through the coding process, which is a form of programming language. The implementation phase is the application of the system design phase.

5. System Maintenance

During implementation, errors that were previously undiscovered may still occur, or new features may be added that were not yet available in the system. Development is necessary when changes are made to the system to make it easier to understand, or when problems arise when the application is being used.

3. Results and Discussion

Based on the existing marker scanning process, the next step is to analyze the process. The process performed on the running system can be implemented using a flowchart, as shown in Figure 2.

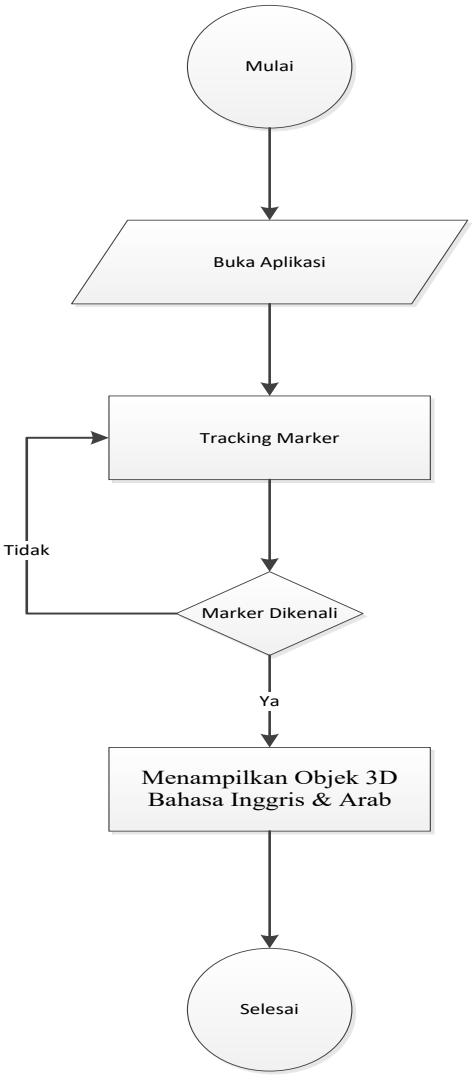

Figure 2. Flowchart of the Marker Scanning Process in the Application

The tracking system used in AR applications must provide high accuracy, low latency, and be robust to environmental changes. The Marker-Based Tracking method involves focusing the visual camera on the marker, detecting its position by identifying the marker. The cameraman then detects the 3D object on the marker and projects the 3D object onto the marker in real time. An illustration of the Marker-Based Tracking method can be seen in Figure 3 below:

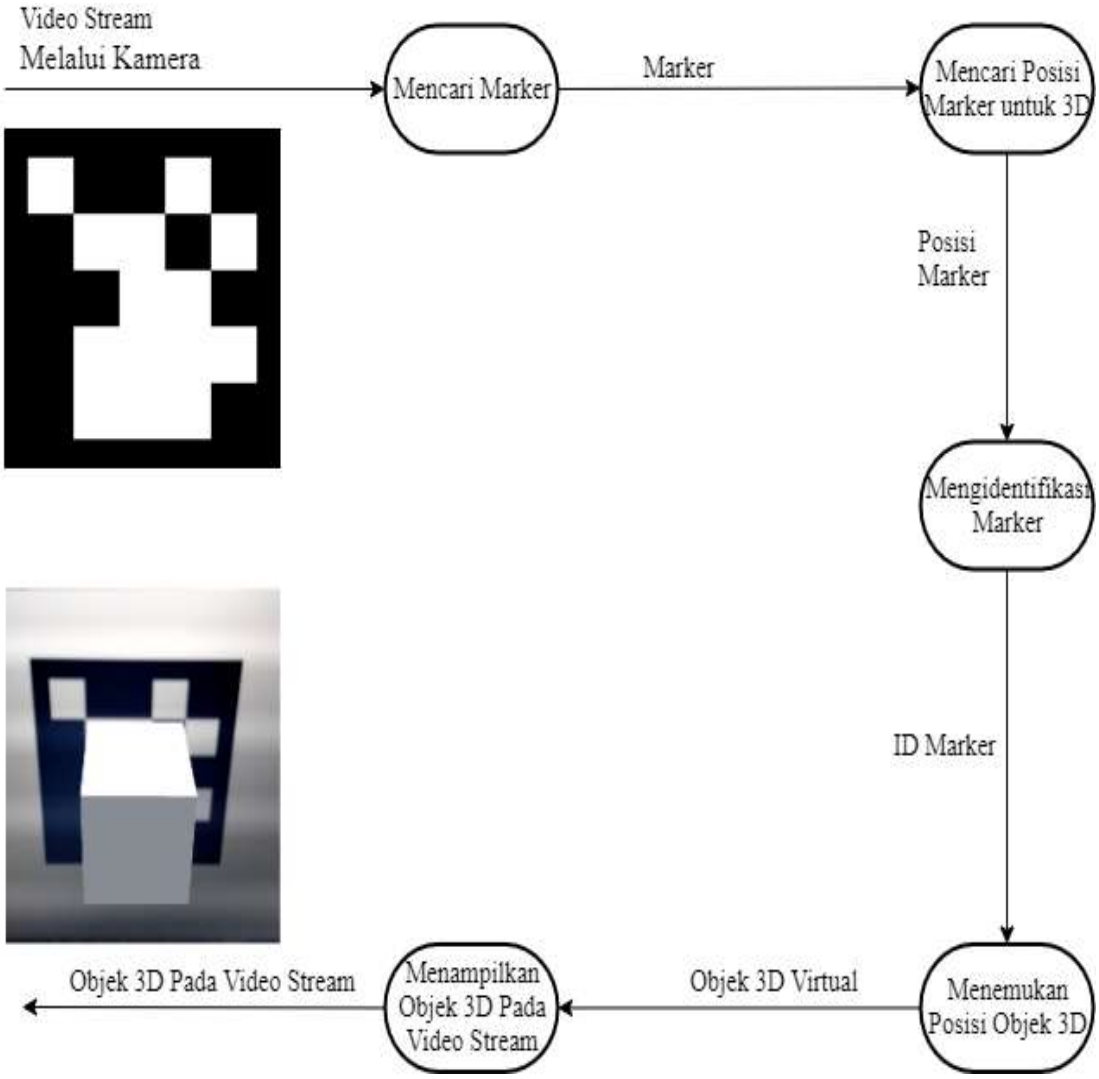

Figure 3. Marker-Based Tracking Workflow

Creating a marker in this markerless environment requires an image file with the extension *.JPG/JPEG, which will then be uploaded to Vuforia. The uploaded marker will be assessed for quality by the system, as shown in Figure 4 below:

Figure 4. Marker Detection

To create a marker in Vuforia, we must first register the object to be used as the marker on the Vuforia website. This is necessary because there is no tool for creating custom markers in the Unity Engine. The steps for marker registration are as follows:

1. Log in to the Vuforia developer site at http://www.developer.vuforia.com.
2. Click the target manager menu, as shown in Figure 5 below.

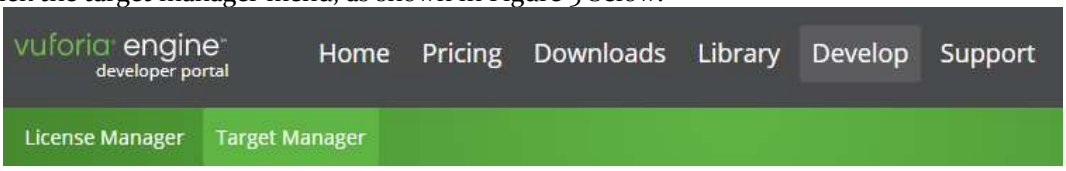

Figure 5. Vuforia Target Manager Menu

3. Click on the previously created database to add the target image.

Figure 6. Vuforia Target Manager Database

4. Click the Add Target button to add a marker to the Vuforia database.

Figure 7. Add Vuforia Target Manager

5. Fill in each field on the Add New Target form according to the existing requirements.

Figure 8. Vuforia Add New Target Field

6. Click the Add button.

7. Target image registration is complete. The form display for successfully registered objects will be as shown in Figure III.8 below:

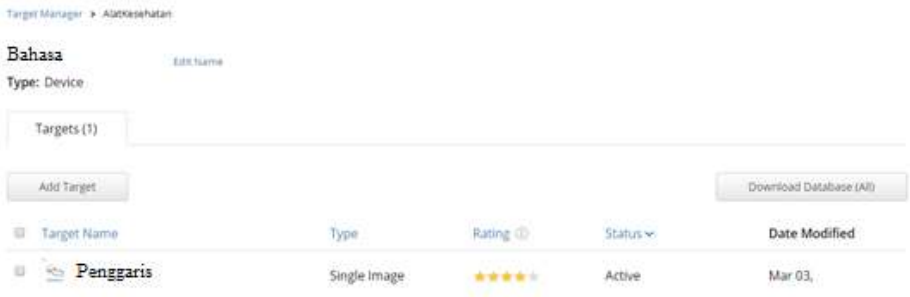

Figure 9. Vuforia Target Image Form

The following explains the results of the "Application of Augmented Reality Technology in Foreign Language Learning (English-Arabic) Using the Marker-Based Tracking Method" application at Bimbel Forward:

1. Main Menu Scene Display
The system displays the Main Menu display in Figure 10:

Figure 10. Main Menu Scene

The main menu scene in Figure 10 is the scene displayed when the user first opens the English and Arabic language recognition augmented reality application. The main menu scene contains five buttons: the start button, which displays the Augmented Reality marker scan scene; the AR cam button, which displays the Augmented Reality scene; the quiz button, which displays the quiz; the about button, which displays information about the app's creator; the material button, which displays learning materials; and the exit button, which exits the app.

2. Displaying the Marker Scan Scene
The system displays the Marker Scan Scene as follows:
1. Indonesian - Arabic

Figure 11. Food Marker Scan Scene

Figure 12. Friend Marker Scan Scene

Displaying the Quiz Scene

The system displays the quiz scene as shown in Figure 13:

Figure 13. Quiz Scene

The quiz scene appears when the user clicks the quiz button in the main menu. This scene displays a foreign language learning quiz.

4. About Scene Display

The system's display for displaying the About Scene is shown in Figure 14, as follows:

Figure 14. About Scene

The About Scene will appear when the user clicks the About button in the main menu. This scene displays information from the developer of the Augmented Reality Foreign Language Learning (English-Arabic) application.

4. Material Scene Display

The system's display for displaying the Material Scene can be seen in Figure 15, as follows:

Figure 15. Material Scene

The Tutorial Scene will appear when the user clicks the Material button in the main menu. This scene displays information about the short learning material for the Augmented Reality Foreign Language Learning (English-Arabic) application.

Discussions

The results of the "Application of Augmented Reality Technology in Foreign Language Learning (English-Arabic) Using the Marker-Based Tracking Method" demonstrate the effectiveness of AR as an interactive learning medium that enhances students' engagement and understanding of foreign languages. The application's main menu provides an intuitive interface, allowing users to navigate easily between key functions such as marker scanning, augmented reality visualization, quizzes, learning materials, and information about the developer. The marker scanning process, implemented using Vuforia and Unity, enables precise detection and tracking of physical markers, which are registered and evaluated in the Vuforia database to ensure high-quality recognition. The system projects 3D virtual objects onto real-world markers in real time, allowing students to experience immersive and contextualized language learning scenarios. For instance, when scanning a food-related marker, the corresponding Arabic term is displayed along with pronunciation guidance, while scanning a "friend" marker similarly introduces vocabulary in a meaningful context. The integration of a quiz feature reinforces learning by providing immediate feedback, encouraging students to actively recall and apply newly acquired knowledge, while the material scene presents concise, structured content that supports independent study. The application's design emphasizes both engagement and accessibility, as students can learn anytime and anywhere using commonly available devices, mitigating traditional barriers such as limited classroom time or unengaging media. Furthermore, the use of marker-based tracking ensures accuracy and responsiveness, even in varying environmental conditions, thereby maintaining the reliability of the AR experience. Overall, the system combines visual, auditory, and interactive modalities to support multiple dimensions of language acquisition, from vocabulary recognition to pronunciation practice, in a cohesive platform. This suggests that AR-based learning applications, when carefully designed with appropriate tracking methods and pedagogical integration, can effectively enhance motivation, interactivity, and comprehension in English and Arabic learning. The implementation in Bimbel Forward illustrates the practical

applicability of this approach and provides a foundation for further studies examining long-term learning outcomes, scalability, and adaptation to other languages or educational contexts.

4. Conclusion

The present study demonstrates that the implementation of Augmented Reality (AR) technology using the Marker-Based Tracking method significantly enhances students' engagement, motivation, and comprehension in English and Arabic language learning. The main findings indicate that the interactive projection of 3D virtual objects onto real-world markers facilitates contextualized vocabulary acquisition, pronunciation practice, and reinforcement through quizzes, enabling students to learn in a more immersive and flexible manner compared to conventional teaching methods. These results have important pedagogical implications, suggesting that AR-based learning applications can serve as effective supplements to traditional curricula, particularly in contexts where student interest and exposure to foreign languages are limited. By integrating visual, auditory, and interactive modalities, the system supports multiple dimensions of language acquisition and provides a scalable approach for self-directed and blended learning environments. However, the study has several limitations, including its focus on a relatively small sample within a single learning institution, reliance on short-term intervention, and constraints associated with device availability and environmental conditions affecting marker detection. Future research should address these limitations by conducting longitudinal studies across diverse educational settings, exploring adaptive AR designs that can accommodate varying learning styles and proficiency levels, and investigating the integration of markerless AR or multi-marker tracking to reduce hardware dependency. Additionally, incorporating systematic assessment of long-term retention and transfer of language skills would provide more robust evidence of the pedagogical effectiveness of AR applications. Overall, this study highlights both the potential and the practical challenges of deploying AR in foreign language education, offering a foundation for subsequent investigations aimed at optimizing AR-mediated learning experiences for broader student populations.

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