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Implementation of Augmented Reality for Javanese Script Recognition Using FAST Corner Detection Algorithm

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Article Info

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Keyword

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Abstract

The aim of this research is to design and develop an Augmented Reality (AR) application to help junior high school students learn and recognize Aksara Jawa by leveraging the FAST Corner Detection algorithm and Marker-Based Tracking techniques to enhance interactivity and engagement. Using AR technology, students can explore Aksara Jawa characters in an engaging way, with 3D objects displayed in real time as they scan designated markers. The research methodology involves literature review, observation, and interviews with educators, while the application development follows the Multimedia Development Life Cycle (MDLC) to ensure quality. Testing shows the application accurately detects markers and displays 3D objects for the intended characters, and feedback from both teachers and students confirms its effectiveness and appeal. Further development of features and content is recommended to make the application even more beneficial and aligned with the needs of Aksara Jawa language education.

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1. INTRODUCTION

The rapid advancement of technology in the era of the Industrial Revolution 4.0 has brought significant transformations in the education sector, shifting traditional teaching methods towards more interactive and engaging approaches. One of the emerging technologies that supports innovative learning is Augmented Reality (AR), which blends virtual elements into the real-world environment in real time to enhance user experience and understanding [1].

In several regions of Indonesia, such as Central and East Java, Javanese language education remains part of the local curriculum, with Javanese script (Hanacaraka) being an essential component. However, conventional teaching methods often fail to attract students' interest, as learning Javanese script is perceived as difficult and monotonous [2]. To address this issue, AR can be utilized as an interactive medium, enabling students to visualize 3D models of Javanese characters and hear their pronunciations, thus increasing motivation and engagement in learning [3].

The accuracy and stability of AR systems rely on effective tracking techniques. Marker-based tracking, combined with computer vision algorithms, enables the system to recognize specific patterns or images (markers) to trigger the display of digital content [4]. The Feature Accelerated Segment Test (FAST) Corner Detection algorithm is one such method, providing fast and efficient detection of corner points in images, making it suitable for real-time applications [5].

Previous studies have explored the application of AR in educational contexts, including cultural and language learning. However, most research on AR-based Javanese script learning did not explicitly discuss the algorithm used for feature detection [6][7]. Other studies have implemented FAST Corner Detection in various domains, such as atmospheric layer education [8] and fish literacy [9], but not specifically in Javanese script recognition.

This study aims to develop an AR application for Javanese script recognition using FAST Corner Detection, evaluate its performance in terms of accuracy and response time, and assess user feedback from both students and teachers. The findings are expected to contribute to the development of engaging digital learning media that preserve local cultural heritage while enhancing the learning experience.

2. METHOD

This research employed a developmental research approach using the Multimedia Development Life Cycle (MDLC) model, which consists of six stages: concept, design, material collecting, assembly, testing, and distribution [10]. The method was selected for its structured and iterative workflow, enabling systematic integration of multimedia elements into the AR learning application.

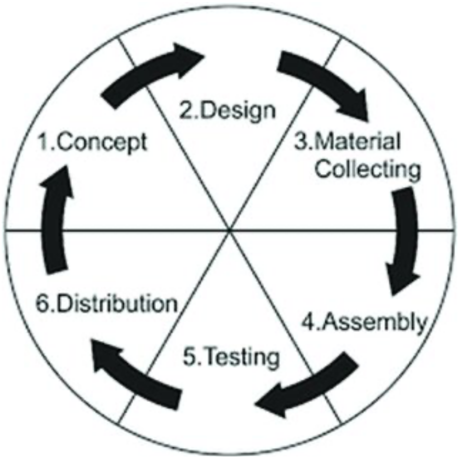

Figure 1. MDLC

2.1 Concept

The primary goal was to design an AR-based application for Javanese script recognition aimed at junior high school students. Key features included marker scanning, displaying corresponding 3D Javanese characters, and playing pronunciation audio. Target users were students and teachers in cultural and language education contexts.

2.2 Design

The design process involved analyzing system requirements, creating use case diagrams, activity diagrams, class diagrams, and sequence diagrams to model application functionalities. The user interface (UI) was designed for intuitive navigation, with a main menu providing access to *Start AR*, *Guide*, and *Exit* features.

To illustrate the interaction between the user and the system, a system model was created using a use case diagram, as shown in Figure 2. This diagram serves to clarify the roles of the actors (users) and the main functionalities available during the application's usage. The model also acts as a reference in designing the interface and defining the navigation flow of the developed system.

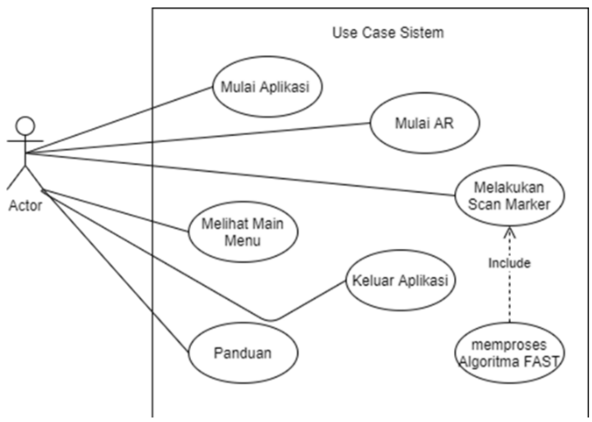

Figure 2. Use Case App

2.3 Material Collecting

Learning materials consisted of 20 basic Javanese characters (Hanacaraka) [2]. Custom 3D models were created using Blender, while marker images were designed and processed in Vuforia to ensure high corner point quality, as evaluated by the FAST Corner Detection algorithm [5]. Audio recordings for each character were produced to provide correct pronunciation guidance.

2.4 Assembly

The application was developed using Unity 3D as the primary development platform, Vuforia SDK for marker-based tracking, and the FAST Corner Detection algorithm integrated through Vuforia's computer vision pipeline. Programming logic was implemented in C# to manage AR interactions, object rendering, and audio playback.

To enhance the accuracy of marker detection, the FAST algorithm integrated with the Vuforia tracking system is utilized. This algorithm detects corner points on marker images quickly and efficiently, enabling the system to accurately recognize markers and display digital objects in real time.

FAST operates by analyzing the pixel intensity within a circle of 16 pixels surrounding the image's center point. If at least 12 pixels have an intensity either brighter or darker than the threshold value, the point is classified as a corner. This detection mechanism is a key factor in the success of image tracking in AR systems.

To ensure fast and accurate detection, the FAST Corner Detection algorithm was implemented. This algorithm identifies distinctive corner points within a marker to assist in robust tracking. The process stages are as follows (Figure 3–7):

1. Initial Point Selection – A candidate pixel is chosen on the marker image as a potential corner point

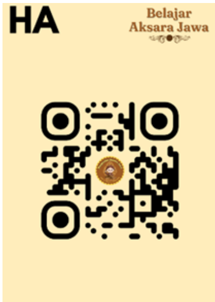

Figure 3. Marker used in the application

2. Surrounding Point Identification – The 16 surrounding pixels in a circular pattern are considered, with an initial comparison often made using four reference points.

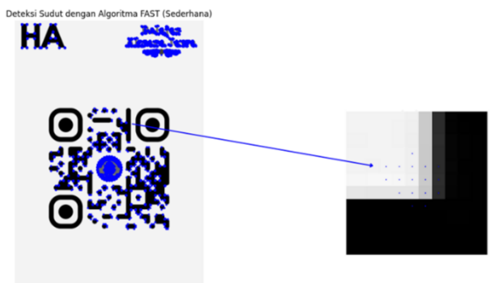

Figure 4. Randomly selected candidate points.

Figure 5. Determination of Surrounding Points

3. Intensity Comparison – The brightness of the candidate point is compared to surrounding pixels. If the intensity difference exceeds a threshold, the point is marked as a potential corner.

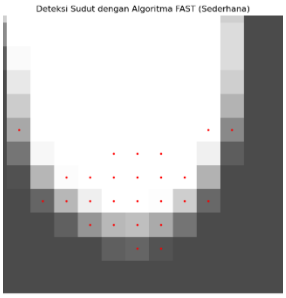

Figure 6. Pixel intensity comparison.

4. Corner Validation – Points meeting the contrast criteria are classified as corners.

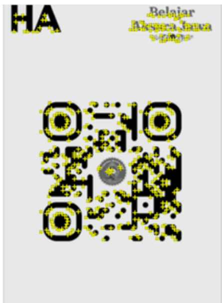

Figure 7. Final selected corner points

5. Iteration and Selection – The process repeats for all pixels, selecting only the strongest corners while removing duplicates.

2.5 Testing

Two levels of testing were conducted:

1. *Alpha testing*: Performed internally by the development team using black-box testing to verify functional requirements [11].
2. *Beta testing*: Conducted with 30 respondents (students and teachers) to assess usability, stability, and educational effectiveness. Performance metrics included marker detection accuracy, response time, and user satisfaction ratings.

2.6 Distribution

The final application was packaged for Android devices (minimum API level 29) and distributed through Google Drive for evaluation purposes.

3. RESULTS AND DISCUSSION

3.1 Implementation

The application was developed using Unity 3D and Vuforia SDK, with 3D objects and audio linked to markers representing Javanese script characters. When a marker was scanned, the corresponding 3D character model and its pronunciation audio were displayed in real time.

The main features were organized into three primary menus:

1. Start Learning – launches the AR camera to scan Javanese script markers and display the corresponding 3D object with audio pronunciation.
2. Learning Guide – provides instructions for operating the application.
3. About Application – contains information about the app and its educational purpose.

Figure 8. Main Menu Interface

Figure 9. Start Learning feature

Figure 10. Learning Guide page

3.2 Alpha Testing

Alpha testing was conducted internally using black-box testing to verify the application's functionality according to predefined requirements [11]. All main features—marker scanning, 3D object display, and audio playback—functioned as expected. The application successfully recognized markers at distances of 10 cm, 20 cm, and 30 cm, with stable tracking and minimal jitter. Table 1 shows the detection accuracy and average response time for each distance.

Table 1 Marker detection performance in alpha testing.

Distance	Detection Accuracy (%)	Avg. Response Time (s)
10 cm	100	0.41
20 cm	96.7	0.49
30 cm	90.0	0.55

The results indicate that the FAST Corner Detection algorithm maintained high accuracy even at increased distances, although slight delays and reduced stability occurred at 30 cm. This is consistent with findings by Pangestu et al. [8], who noted that marker tracking performance decreases with distance due to reduced image resolution and corner point clarity.

3.3 Beta Testing

Beta testing involved 30 participants, comprising junior high school students and a Javanese language teacher. Respondents used the application and completed a usability questionnaire. The evaluation covered ease of use, visual quality, audio clarity, and perceived usefulness.

The average usability score reached 86.3%, categorized as "very good" according to the SUS (System Usability Scale) interpretation [12]. Participants highlighted that the 3D visualization and audio pronunciation significantly improved their understanding and retention of Javanese script. Teachers noted that the AR approach increased student engagement compared to conventional teaching methods, aligning with previous studies on AR-based cultural learning [6][7].

3.4 Discussion

The integration of FAST Corner Detection with marker-based tracking proved effective in providing fast and stable marker recognition. The corner detection algorithm contributed to maintaining performance in varying lighting conditions and distances, which is crucial for classroom environments where lighting cannot always be controlled.

Compared to prior AR implementations for Javanese script learning [6][7], this study explicitly applied and evaluated FAST Corner Detection, offering measurable performance metrics in terms of accuracy and response time. Furthermore, the combination of visual and auditory learning elements supported multiple learning styles, consistent with multimedia learning theory [13].

4. CONCLUSION

This study successfully developed an Augmented Reality (AR) application for learning and recognizing Javanese script (Aksara Jawa) using the FAST Corner Detection algorithm and marker-based tracking. The application was built with Unity 3D and Vuforia SDK, displaying 3D character models and pronunciation audio when specific markers were scanned.

Alpha testing results showed that the system achieved high marker detection accuracy (up to 100% at 10 cm) with low average response times, demonstrating the efficiency of the FAST algorithm in real-time AR applications. Beta testing involving students and teachers indicated a high usability score (86.3%), categorized as "very good," and revealed positive feedback regarding the application's ability to enhance learning motivation and engagement.

The integration of visual and auditory elements within an interactive AR environment proved effective in supporting the learning of Javanese script, making it a potential supplementary tool for cultural and language education. Future work may focus on expanding the marker set, adding gamification elements, and optimizing performance for various mobile devices.

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