Enhancing the Transliteration of Words written in Javanese Script through Augmented Reality

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ABSTRACT

In the Special Region of Yogyakarta Province and Central Java Province, where most of the population is Javanese, the use of Javanese script in daily life is increasingly replaced by Latin script, endangering the further loss of the Javanese identity. This research describes the development of marker-based Augmented Reality (AR) technology to create a Javanese word-reading application. The markers in printed Javanese characters are taken from a Javanese script manuscript entitled Hamong Tani. The markers can be arranged in various ways by the user to form words, with the maximum number of markers that make up words being 5. Whenever the camera is aimed at a row of markers that make up words, additional information will come out as translation results written in Latin. The results of testing the application called Jawalens, which was developed deploying the Multimedia Development Life Cycle (MDLC) method, on 38 users show that it has high levels of usefulness, satisfaction, and ease of use. It is hoped that Jawalens can help the younger generation re-learn and read Javanese scripts. Apart from that, the development method described in this paper is expected to inspire the younger generation in other regions or countries to develop similar applications, and thus help preserve their ancient scripts.

Keywords-augmented reality; Javanese script; MDLC; transliteration

I. INTRODUCTION

According to Yudho Giri Sucahyo, chairman of Pandi or the Indonesian Internet Domain Name Manager, the number of characters in Indonesian scripts is 718. The scope of the script's spread is from Sabang to Merauke, while Javanese script can be also found in DIY and Central Java [1]. Similarly to what applies to other regions' scripts, Central Java's concern for people to preserve the Javanese script is increasingly diminishing. This is mainly caused due to the emergence and utilization of Latin script that is widely employed in everyday life, for example, in various reading materials, publications, or information boards. If Latin's extensive utilization continues, the Javanese script will be entirely forgotten. Therefore, it is necessary to recur to technological breakthroughs, which can arouse young people's interest, for the nation's next generation to start recognizing Javanese script again. One way to accomplish this is by employing the smartphone device in which an Augmented Reality (AR) application can be installed for transliterating Javanese script.

AR is widely deployed in Indonesia and Malaysia to reintroduce regional scripts to the younger generation. For instance, AR can assist students increase their motivation to learn the Ka Ga Nga Rejang Lebong script [2]. Regarding the AR application employment for the Lampung script comprehension, the former can help introduce Lampung script quickly because it can be accessed with a camera in real-time and can be utilized as a fun variation of learning media [3]. Authors in [4] conducted a research exploring the effectiveness of the AR application for learning Jawi script on 27 users. The latter took part in beta testing for the application's efficiency to be studied. It was stated that 81.5% of the respondents strongly agreed that the application made learning Jawi script easier and 74.1% of them agreed that the application had increased their Jawi script knowledge. Consequently, the AR application contributed to preserving the Jawi script and communicating knowledge in a more efficient, simple, and convincing way. AR is regarded an adequate medium for learning Sundanese script [5]. Learning media development through the utilization of AR technology, which aims to help children visually understand the form of Javanese script and how to write it, demonstrates that the application performance results render it very suitable for use. However, it is considered that AR must be further advanced to be improved [6].

Another interesting research discusses the development of Javanese language educational games employing Android-based AR technology. The evolution of educational games helps introduce Javanese writing to the public, especially children. AR is used to represent natural objects into virtual objects in 3D images, video, or audio allowing children to see Javanese characters more interestingly and interactively. Since it is a game, it will enable children to learn Javanese script in a more entertaining and interactive way. So, it is hoped that it can increase interest in learning and preserving shared culture [7]. An additional intriguing AR application involved students with special needs, namely deaf students at Skh YKDW 02 Tangerang. AR was utilized to teach students Hijaiyah letters. It was concluded that AR helps students learn the Al-Quran due to its visual and interactive display, which introduces them to the concept of Hijaiyah letters [8].

This paper presents a methodology for developing a Javanese script word-to-Latin script transliteration called Jawalens using AR. The transliteration of words, rather than scripts, was performed inspired from the research conducted in [9], which stated that the word recognition approach in developing OCR engines was more effective.

II. JAWALENS DEVELOPMENT METHODOLOGY

The Jawalens was developed using the Vaughan's multimedia development model approach. This method was chosen because it was considered suitable for the present research. The model, which can be repeated, consists of three main stages [10].

The analysis stage is for determining goals, identifying user needs, and collecting relevant information and materials for the application. This process involves conducting user surveys and interviews to understand their needs and preferences, as well as gathering data and materials related to the Javanese language and culture, which are crucial for the development of the application's content and features.

The design and production stage of the Jawalens application was meticulously planned and executed. This comprehensive approach ensured that the idea was fully developed and its implementation was well thought out. The development of the prototype involved formulating ideas to determine the visual representation of AR, planning the visual flow and layout, and selecting the hardware and software for application development. This detailed planning instills confidence in the development process, assuring the audience of the application's quality.

In the testing and distribution stage, rigorous testing was carried out to ensure that all application elements work well and according to plan. The involvement of several end users in testing the project and providing feedback is not just a formality but a substantial part of the process. This user feedback, which is highly valued and integral in identifying potential issues and certifying the application's final goals are met, plays a significant role in making the audience feel appreciated for their contribution.

A. Dataset Collection of Javanese Script Markers in Jawalens

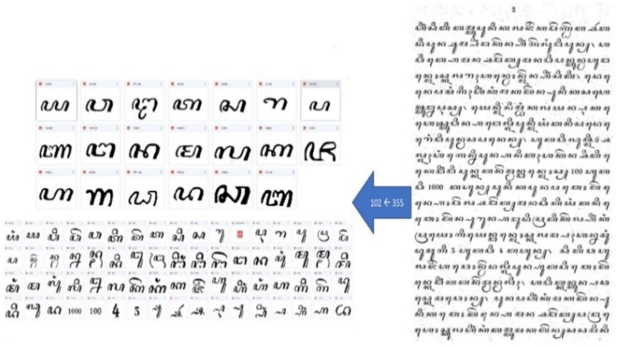
A marker contains a particular design that the camera will recognize. A 2D or 3D object can be shown when the camera recognizes the marker. Markers, also known as picture targets, adhere to specific criteria within the AR system, which are crucial for successful implementation. These criteria entail [11]:

- The image features are intricate, such as landscape images, pictures of crowds, collages, and more, adding to the complexity of the marker.
- There is no redundancy of designs for illustration, grass areas, or boxes.
- Color designs are 8 or 24-bit PNG or JPG arranged, estimated as less than 2MB; JPGs must be RGB or grayscale (not CMYK).

One of the meticulously conducted research activities to develop Jawalens is the creation of Javanese script markers. Those markers serve as the objects scanned for the application of input data. Drawing from the insightful research carried out in [12], it was discovered that there are 11274 unique forms of Javanese script. However, in this particular research, the markers used are limited to pictures of printed Javanese script, specifically derived from [13]. The book's pages are in good condition, and its popularity among the users of the Artati library, where the book is housed, prompted researchers to capture images of the printed Javanese characters to use them as markers. The steps taken to obtain images of Javanese characters, which became markers are:

- Scanning the pages of the book that is the reference source.
- Automatic segmentation to obtain units of Javanese script images.
- The image processing steps are executed precisely on the segmented image, including processes to reduce noise and change the image size. This ensures that the image can be used as a sensitive marker. In this case, all markers have a star attribute, a meticulous detail, to guarantee that the camera can easily detect the marker when capturing it.
- All Javanese script images were uploaded into Vuforia for the latter to be saved as a marker database.

When this publication was carried out, the primary data source was obtained from the segmentation and preprocessing results on the second page of the book in [13]. Figure 1(b) portrays the source of the image on the second page. The Javanese script marker dataset can be grouped into two categories: the primary Javanese script marker group, *nglegena* script, and the non-*nglegena* script. The marker for the Javanese *nglegena* script contains data on 20 script images, as observed in Figure 1(a) at the top, namely the scripts *ya, wa, tha, ta, sa, ra, pa, nya, nga, na, ma, la, ka, ja, ha, ga, da, da, ca*, and *ba*. From the study of the *nglegena* script forms, it can be found that there are many similarities between them. The components that make up a marker are only vertical, horizontal, and curved lines that open downwards or upwards. This creates difficulties, considering that a good marker is a genuinely unique marker. Therefore, in realizing the uniqueness of the markers in some characters, small noises are still left, which are not visible to the naked eye.



(a) Collected marker. **(b) Source marker.**

Fig. 1. Illustration of the primary source of markers and the results of the markers.

This is different from the marker shapes for the non-*nglegena* Javanese script, as evidenced in Figure 1(a). The additional components in the *nglegena* Javanese script, such as *sandangan* and *pasangan*, make the character's shape unique, so there is no need to provide additional information in the image. All 76 markers can be downloaded from [18].

B. Method of collecting Word Markers

- The markers developed in this research contain Javanese scripts and a collection of Javanese scripts that form words. These word markers are markers produced from developing the Javanese script marker dataset. Developing word markers each time can be done independently. However, the rules for placing markers must be the same as those for writing Javanese script [14].
- In this initial research, words composed of 5 Javanese scripts were used based on research regarding the number of syllables [15-16] and the maximum number of markers that Unity can scan at one time. Figure 2 illustrates some markers that can be utilized to play with Jawalens.
- Figure 2 contains eight word markers, some consisting of 2, 3, or 4 Javanese script markers.

Fig. 2. Example of word markers.

C. Design of Jawalens Application Menus and Aset AR

The Jawalens application will have the following AR menu design describing its appearance (Figure 3(a)). The Jawalens application design will contain four menu items on the main page. The user will use the Play item to enter the core AR application. By clicking the Play menu, the smartphone camera will activate the search for the marker and display the results of the translation of the Javanese script depicted on the marker. The About item will direct the user to a page containing information about general matters related to the Jawalens application. The Credit menu item will direct the user to a page about the application development team. The Exit menu item will make the application close the program.

(a) **(b)**

Fig. 3. Design menu of Jawalens application.

Two submenu buttons will appear on the Play menu page or when playing AR. As displayed in Figure 3(b), the button with the camera icon at the bottom right will activate taking pictures from the smartphone's screen. This feature allows users to capture and save the translated Javanese script for future reference. On the other hand, the button with the arrow-pointing-left icon functions as the back button, allowing users to navigate back to the main menu or the previous page, enhancing the application's user-friendliness.

The main concern in the AR development design for transliteration is the selection of scripts as markers because there are so many unique forms of Javanese script after adding various punctuation marks according to the rules for writing Javanese script. Meanwhile, the concept for developing assets is straightforward: directly displaying the transliteration results without much animation or complicated 3D designs. It is only a matter of considering the type of font, font size, and font color that it is, according to the user's wishes, simple and does not interfere with the primary goal, namely transliteration, as seen in Figure 4. If the camera detects Javanese script, the AR application will display the transliteration results near the Javanese Script. It is in the form of Latin script (Figure 4).

Fig. 4. Design menu of Jawalens application.

III. RESULTS AND DISCUSSION

Unity and Vuforia, industry-standard software for AR development, were deployed in the implementation stage. These well-established tools provide a solid technical foundation for the application, ensuring reliability and performance. Unity is used to develop the application's core functionalities, while Vuforia enhances AR marker recognition and tracking, improving the application's AR capabilities.

The Play menu, as depicted in the user-friendly design in Figure 3(b), provides a seamless experience for users to engage with augmented reality. Figure 5 shows the layer on the smartphone when the Play button is pressed. The camera captures a marker of 2 Javanese characters, each translated from left to right as pra and hu. The camera is some centimeters away with sufficient lighting and is in front of the marker image. The green writing that appears right above the Javanese script results from the translation of the Javanese script.

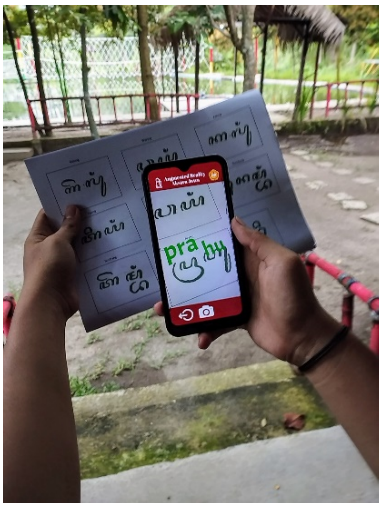


Fig. 5. Example of JawaLens work: all Latin script with green color are augmented on the top of each Javanese script.

The JawaLens application was rigorously tested on various smartphones, including popular Xiaomi, Samsung, and Oppo models. These devices, all running on Android, version 10 or higher, varied in specifications such as RAM capacity (minimum 2 GB), and operating system. The specific models employed in this research were Xiaomi Redmi 8, Redmi Note 11, Samsung Galaxy A54, Samsung Galaxy A10s, Samsung Galaxy A14 5G, Samsung A54 bi, and OPPO A5 2020, ensuring a comprehensive evaluation of the application's performance across different platforms. Various sizes are obtained from multiple AR application experiments, as shown in Table I. For example, with the smallest Javanese script size being 2 × 2 cm, for the AR application to function correctly, the smartphone camera must be placed at least 5 cm from the scanned Javanese script and at the furthest distance of 9 cm. The application failed to scan smaller character sizes. Likewise, if the camera was moved further than 9 cm, the image of the Javanese script becomes increasingly blurry, resulting in the AR application not functioning correctly.

TABLE I. SCRIPTS IMAGE SIZE AND DISTANCE OF CAMERA TO MARKER

Javanese script size (cm)	Distance of camera to marker (cm)	
	Minimum	Maximum
2 × 2	5	9
3 × 3	5	12
4 × 4	6	16
4.5 × 4.5	6	18
5 × 5	8	22
6 × 6	7	20.5
6.5 × 6.5	10	26
7 × 7	9	27
8 × 8	10	30
9 × 9	14	37
10 × 10	16	40
11 × 11	18	46

Based on Table II, it can be observed that the speed of 3D image output when the marker is scanned using the Redmi Note 11 Android Version 13 cellphone with 4 GB RAM, 128 GB Internal, Snapdragon 680 Octa-Core 2.40 GHz specifications varies depending on the light intensity used. The system's performance is noticeably affected in low light conditions (10 lux). The average time for a 3D image to appear is around 6.329 s, indicating a more extended recognition and display time due to the suboptimal lighting. In medium light conditions (20 lux), the 3D image output time is reduced to around 3.639 s. This increase in light intensity helps the system recognize the marker faster, so the response time becomes shorter. In high light conditions (30 lux), the average time for a 3D image to appear is 2.468 s. With better lighting, the system can quickly recognize the marker and display the 3D image, showing optimal efficiency. The current study unequivocally demonstrates that the speed of 3D image output time is proportional to the light intensity. Improved lighting conditions significantly accelerate the process of marker recognition and 3D image display, culminating in a more responsive and user-friendly experience.

TABLE II. COMPARISON OF AUGMENTED REALITY RESPONSE TIME BASED ON LIGHT INTENSITY

Marker	Power of light (lux)		
	10	20	30
Mireng	5.23	2.87	2
Tembang	3.07	2.41	2.14
Wayang	6	5.57	3.27
Jengkang	3.36	2.29	2
Tiyang	10	5.84	2.89
Keli	5	4.77	4.48
Guru	6.39	5	2
Prahu	6.53	3.22	2
Huntu	8.49	2.21	1.9
Kali	9.22	2.21	2
Average time (s)	6.329	3.639	2.468

Software quality can be assessed through specific measures and methods and software tests. One benchmark for software quality is ISO 9126. In this research, software quality testing focuses on the usability factor, namely the ability of the software to be understood, studied, used, and attractive to users [17]. The USE questionnaire was a reliable tool for evaluating the JawaLens application. This questionnaire, designed to measure usability, satisfaction, and ease of use, is highly relevant to the present research’s objectives. Its structured format and standardized questions allow for a systematic and comprehensive assessment of the application's quality, thus increasing the reliability of this study's findings. Table III manifests the distribution of the 38 respondents who have used Jawalens. There are three groups of respondents, the largest of which are undergraduate students in their second semester.

Table IV exhibits the contents of the questions asked to the users and the average value of user answers, where each user is asked to provide an assessment with a value range of 1-5 for each question. A value range 1 means that the user strongly disagrees with the statement. The user survey results are promising. The average score of 4.298 from 38 respondents, who were asked to rate the usefulness criterion indicates an excellent level of usability. This high average score, along with the majority of respondents giving a very high assessment, suggests that the product will be likely very satisfying to users in terms of usability and provide high value to them.

TABLE III. USER CLASS DISTRIBUTION

User status	User count
Students	25
Lecturer	5
General Public	6

TABLE IV. EFFECTIVITY TEST OF THE JAWALENS APPLICATION

Question	Avg. score
Usefulnes	
Is it easy for you to download the JavaLens application?	4.344
Is it easy for you to install the JavaLens application?	4.263
Is it easy for you to operate the JavaLens Applications?	4.289
Satisfaction:	
Are you like the user interface of the JavaLens application?	4.079
Is the photo capture feature easy to use?	4.079
Is the photo capture does it work well?	3.974
Ease of Use	
Are you able to recognize markers the JavaLens application?	4.026
Are you understand symbols in the application without difficulty?	4.211
Can you easily recall the user interface and display of the JavaLens application?	3.895
Please rate your overall experience with JavaLens on a scale of 1-5.	4.105

The average overall experience score of 4.105 shows that the product received a very positive assessment from the respondents. This suggests that the product will likely meet or exceed user expectations.

IV. CONCLUSION AND FUTURE WORKS

The development of an Augmented Reality (AR) system for the transliteration of Javanese word scripts into Latin scripts is a major technological advance. The proposed system uses advanced image recognition algorithms and real-time transliteration capabilities, which offer accurate and efficient Javanese word conversion. This innovation answers the challenges faced in preserving and understanding Javanese literature, providing a valuable tool for researchers and educators. This system requires numerous markers, each corresponding to a unique Javanese character. To ensure the accuracy of the Javanese script image utilized as a marker, the Javanese script has been sourced from an authentic Javanese script book, enhancing the reliability of the proposed system. AR product testing has been carried out on different smartphones. Survey results on users who have used the Jawalens application show high satisfaction with the products assessed. The high average score for usability, satisfaction, and ease of use indicates that the product has a good level of usability, provides high satisfaction to users, and is easy to be used. Most respondents gave high ratings to all three criteria, suggesting that the product is likely to meet or even exceed user expectations. By applying AR to translate words from Javanese to Latin script, people in central Java, can learn again to read Javanese script, and so continue preserving their heritage. The potential of the Jawalens application is vast, as people can create new words from the composition of Javanese markers uploaded in [18]. Further research can develop the Jawalens application for more markers and combine it with artificial intelligence to process markers written by the user's hand, opening up new horizons for cultural preservation and language education.

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