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Visualization of the Batik Cloth Stamping Machine Using Augmented Reality at the Yogyakarta City Crafts and Batik Center

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Abstract

The batik stamping machine is a primary tool used by the Center for Crafts and Batik in the production of batik fabric. This machine has been automated using a Programmable Logic Controller (PLC), allowing it to be controlled via computer. Currently, the machine is only capable of producing 15 sheets of batik fabric per month, which is significantly below the production target of 50 sheets per month. Therefore, innovation is needed to enhance the machine's performance and increase its production capacity. One such innovation is the redesign of the batik stamping machine using augmented reality (AR) technology. AR enables the visualization of 3D images as real-life 3D objects, allowing for design evaluation before proceeding to the physical manufacturing stage, thereby reducing development costs. The development process includes creating detailed technical drawings of the batik stamping machine, complete with dimensions and specifications, and generating a license using the Vuforia Engine to create image markers within the Unity software. The AR implementation uses the single marker method, where each image marker corresponds to a single object, meaning that multiple objects cannot be displayed simultaneously. The use of AR technology in the redesign of the batik stamping machine by the Center for Crafts and Batik marks a significant step toward increasing batik production. Based on the evaluation of the 3D model visualized through AR, the design is considered suitable as a reference for further development. The results of the user acceptance test show a high level of satisfaction, with 95% approval for the machine visualization and 94% for the application interface. Thus, the use of a 3D model before physical production has proven to be an effective approach for evaluating and refining the batik stamping machine, ultimately helping the Center achieve its production goals.

Keywords : The Batik Stamp Machine, Augmented Reality, Visualization, 3D

INTRODUCTION

The Center for Crafts and Batik was established in 1922 under the name "Textile Establishment and Batik Testing Station" with the aim of providing information and support to batik and textile artisans. Over time, it became better known as the Batik Research Center. As the scope of its responsibilities expanded, it evolved into the Batik and Craft Research Center. In 1980, to accommodate growing responsibilities, it was restructured into the Center for Research and Development of the Crafts and Batik Industry. Later, in 2002, in response to the need to align the organization's mission with the practical demands of the industrial and commercial sectors, it was reorganized again into what is now known as the Center for Crafts and Batik.

The batik cloth stamping machine at the Center has dimensions of 300 cm in length, 235 cm in width, and 165 cm in height, and is located at the rear of the building. This machine consists of several main components including the machine frame, a wax-holding canting, and a control unit for operating the machine. Due to various issues, this study focuses on creating a 3D model of the batik stamping machine using Augmented Reality (AR) technology as an effective and innovative alternative for evaluating and improving the machine's design. The purpose is to display the assembly process of the machine's components using AR, enabling thorough evaluation prior to physical production in order to reduce development costs and increase efficiency.

Therefore, the stamping machine must undergo a redesign to improve productivity in batik cloth manufacturing at the Center for Crafts and Batik. Relevant international research addressing similar challenges was conducted by Stearns (2018), who explored novel AR applications that assist users in visualizing and interacting with virtual 3D content anchored in the physical world. The research introduced two prototype systems

within the AR zoom design space, which were refined through user-centered design sessions. Findings highlighted the advantages of using 3D AR tools such as a more natural viewing experience and better multitasking ability compared to traditional handheld tools. However, the study also identified challenges, including a steeper learning curve and hardware limitations. These insights offer valuable guidance for future AR interface and system design.

METHODS

Augmented Reality (AR) is a technology that integrates two-dimensional and/or three-dimensional virtual objects into the real world and projects these virtual elements in real time Elvrilla (2011). Today, the impact of Augmented Reality technology is increasingly evident. It offers numerous benefits and has a wide range of applications across various fields. AR serves as a valuable platform for enhancing experiences in areas such as education, industry, healthcare, entertainment, and more :

Manufacturing

One of the main challenges in the manufacturing sector is designing and implementing an Augmented Reality (AR) integrated system that can enhance the efficiency and effectiveness of the manufacturing process. The ultimate goal is to develop a system that matches or even surpasses real-world performance in terms of accuracy and productivity. Augmented Reality can significantly enhance a person's perception of their surroundings and improve their understanding of product assembly tasks Reinhart & Patron (2003).

Entertainment

Augmented Reality (AR) has been widely applied in the entertainment industry, particularly in the development of interactive games. Additionally, it enhances the visibility of key elements during live sports broadcasts. In such cases, where a large audience is reached, AR can also be utilized by advertisers to display virtual advertisements and product placements. Sports environments such as swimming pools, soccer fields, and race tracks are familiar and relatively easy to prepare for AR applications, enabling video see-through augmentation through tracking camera feeds Krevelen (2012).

Education

In the field of education, Augmented Reality (AR) serves as an effective tool for enhancing the learning experience by providing a more engaging and interactive medium for accessing information. AR enables the visualization of virtual objects or information overlaid on physical objects or real-world environments Arvanitis (2009). AR systems can help students better understand abstract scientific concepts or phenomena that are otherwise difficult to observe—such as airflow, magnetic fields, or molecular structures by using virtual representations like molecules, vectors, and symbols. For example, applications like Augmented Chemistry allow students to visualize and interact with chemical elements in a more intuitive and immersive way.

Military

Augmented Reality (AR) techniques have been utilized for military training and planning, particularly in urban environments. One such application, developed by the company Arcane, uses AR to display animated terrain models that assist in planning military interventions Livingston (2002). Additionally, Canada’s Institute for Aerospace Research (NRC-IAR) developed a helicopter night vision system that incorporates AR to expand the aircraft's operational capabilities and enhance the pilot's navigation in degraded visual conditions Yu (2010). Head-Mounted Displays (HMDs) have also been developed for military use, enabling integration with portable information systems to provide soldiers with real-time data in the field Sanders (2004).

Unity

Unity 3D is a game engine software designed for creating and developing video games. The core features of a game engine typically include a rendering engine for displaying 2D or 3D graphics, a physics engine that enables 3D objects to behave like real-world objects (e.g., affected by gravity or collisions), as well as support for sound, scripting, animation, artificial intelligence (AI), networking, streaming, memory management, multithreading, and animated graphics. There are various game engines available that support game development across multiple platforms, including video game consoles and desktop operating systems such as Microsoft Windows, Linux, and macOS Yulianto (2012).

Single Marker

One of the methods used in Augmented Reality is the single marker method, where one marker is used to display only one 3D object and cannot recognize or display multiple markers simultaneously. The process for implementing this method involves uploading images one by one to Vuforia, where each image is converted into a marker. Vuforia evaluates each image to determine its suitability as a marker, based on factors such as contrast

and pattern clarity typically providing a rating to indicate how well the image will perform in tracking. Once a suitable image is selected, it is designated as the marker for the single marker system. This image is then processed and integrated using Unity software to display the associated 3D object.

User Acceptence Test

User Acceptance Testing (UAT) is a testing process carried out by end users to ensure that the system functions properly and meets their requirements Binus (2017). The purpose of UAT is to validate that the developed system aligns with user expectations and is ready for deployment. The following is the formula used to calculate the User Acceptance Testing (UAT) score, as proposed by Muqsith (2016):

$$Score = \frac{Amount\ Question}{(Amount\ Question\ \ x\ Responden)}\ x\ 100\ \%$$

Information:

Number of answers	: Number of respondents' yes/no answers
Number of questions	: The number of questions asked to respondents
Number of respondents	: The number of respondents who filled out the questionnaire

RESULT AND DISCUSSION

Making Batik Fabric Stamping Machine Images

In creating images for the batik cloth stamping machine, various types of image modeling software can be used. One commonly used software is Autodesk Inventor. This stage serves as the initial step in developing Augmented Reality (AR) technology, as the object to be displayed must first be created as a realistic 3D model.

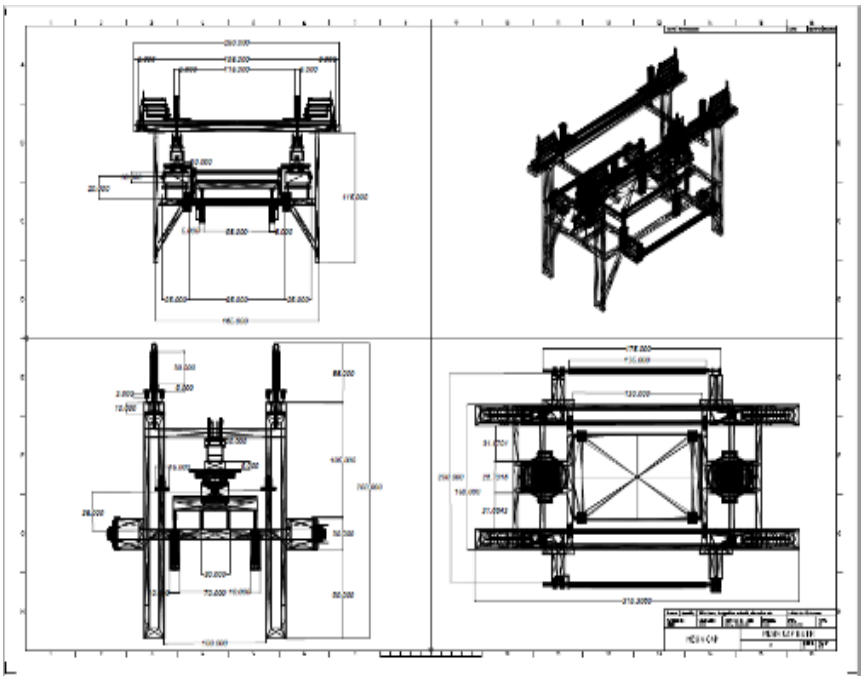

Figure 1. Design Batik Cloth Stamping

Manufacturing Marker

Creating a marker involves selecting an image that will be used as the reference object for the scanning process in order to display the desired 3D content. The image chosen as a marker can either be sourced from a website or created manually. Once a suitable marker image has been selected, the next step is to access the Vuforia Engine website. The login page is used to sign into the Vuforia platform. On the Vuforia website, users can access various tools such as Home, pricing, download, library, develop, and support. For the marker creation process, the relevant tool is found under the develop section. Within this section, there are two main options: License Manager and Target Manager. To proceed with marker creation, the Target Manager option is selected.

Figure 2. Logo Marker

License Creation

Creating a license is a crucial step to ensure that the Augmented Reality (AR) project runs properly and without issues. Without a valid license, the AR object will not appear during the scanning process. To obtain a license, first visit the login page on the Vuforia Engine website and sign in using your registered account credentials.

Figure 3. License Marker

Manufacturing Single marker

A marker is an image used to trigger the appearance of a 3D object at a predefined target. In the single marker method, only one object can be displayed per marker multiple objects cannot be displayed simultaneously. On the Unity interface, several options are available. On the left side of the screen, you will find tabs such as Projects, Learn, Community, and Installs. In the upper right corner, there are options to Add or create a new project, along with the version of Unity being used to develop the project.

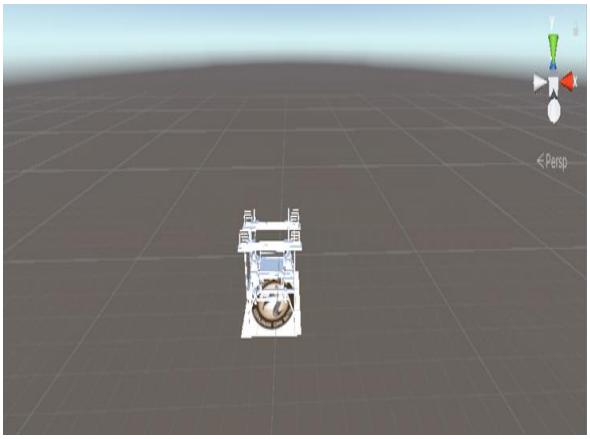

Figure 4. Making Single Marker

Picture Assembly Batik Cloth Stamping Machine

Assembly visualization is the process of combining 3D image components into a complete product. In this case, the assembly of the batik cloth stamping machine is carried out using Augmented Reality through Unity software. This process serves as a means of providing visual information for assembling the batik cloth stamping machine by creating animation sequences within Unity. An important consideration when creating this animation is that the machine model must consist of individual components assembled step by step, rather than being a single, pre-merged object. The following outlines the stages involved in creating the assembly animation using Unity.

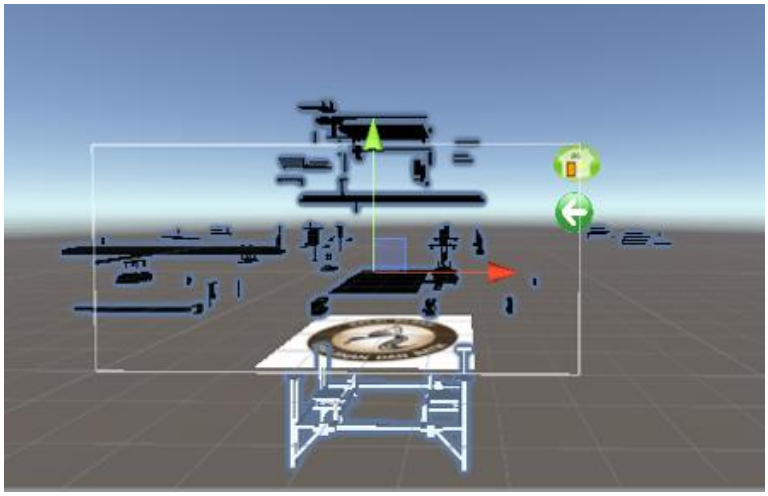

Figure 5. Assembly Drawing

Application Interface Design

The application interface design consists of four main sections: the Center for Crafts and Batik logo page, the Augmented Reality (AR) scan page, the About page (which provides information about the application), and the Exit page to close the application. The main page includes several key elements: the Home button, application logo, start button, about button, and Exit button. Each button serves a specific function. The Start button is used to display a 3D model of the batik cloth stamping machine and activates the camera to scan the designated marker image. The About button provides information about the specifications of the batik stamping machine. The Exit button allows the user to close the application.

Figure 6. User Interface

User Acceptance Test

User Acceptance Testing (UAT) was conducted by distributing questionnaires to employees in the production department at the Center for Crafts and Batik. This test aimed to gather user feedback on the developed application and to assess whether the application successfully addresses the problems identified in the research background. The questionnaire utilized the Likert Scale, a commonly used method for measuring attitudes and opinions, as described by Djaali (2008). Using this scale, respondents are asked to indicate their level of agreement with a series of statements related to the application. These statements represent research variables that are specifically defined by the researcher. The Likert Scale is named after its creator, Rensis Likert, a social psychologist from the United States. Respondents from the Center for Crafts and Batik were presented with

questions related to the application and asked to respond using a five-point rating scale: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD**)** the following is the design of the questionnaire:

Table 1. User Acceptance Test Questionnaire

No	Question	Assessment				
		SA	A	N	D	SD
1.	Can the application be installed on a cellphone? Smartphone other					
2.	What is the appearance of the 3D shape on the batik cloth stamping machine good?					
3.	What is the application running well?					
4.	Does the button on the display of the batik cloth stamping machine work properly?					
5.	Does the application provide information about batik cloth stamping machines?					
6.	What is the Application easy to use					
7.	Does the application run smoothly					
8.	What is the menu in the application appropriate?					
9.	Can the menu you press run?					
10.	Does the camera's AR display work smoothly?					

To draw conclusions from the completed questionnaires, certain evaluation standards can be applied to determine whether the application's usage meets expectations. These standards also help calculate the percentage of user satisfaction. Each response on the questionnaire is assigned a specific weight based on the rating scale. The weight values for each level of assessment are as follows:

Table 2. Linkart Scale

Answer Scale	Information	Score	Presentation
SD	Strongly Disagree	1	0 – 19 %
D	Disagree	2	20 – 39 %
N	Netral	3	40 – 59 %
A	Agree	4	60 – 79 %
SA	Strongly Agree	5	80 – 100 %

$$P = \frac{S}{IDEAL\ SCORE}\ x\ 100\ \%$$

Information:
P : The presentation value you are looking for serch
S : Total Frequency multiplied by the score for each answer
Ideal Score : Highest score multiplied by the number of samples

Main Page Display of the Application

The main page serves to introduce the batik cloth stamping machine application and provides various buttons for proper navigation and usage. There are three main buttons on the application’s main page, along with the application logo.

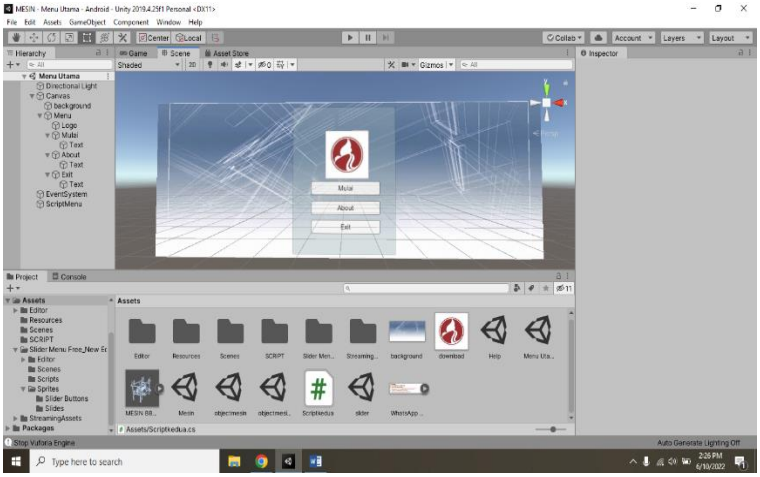

Figure 7. Main Application Page

Page Views Scan AR

This page functions to display information about the batik cloth stamping machine, including its shape and design, which is used in the batik-making process. The animation applied to the 3D model features a rotating motion. To display the 3D object, the batik cloth stamping machine is linked to a pre-defined marker. The developer uses Augmented Reality (AR) technology on the AR Scan page. On this page, the device's camera becomes active and scans the designated marker to detect and render the 3D object.

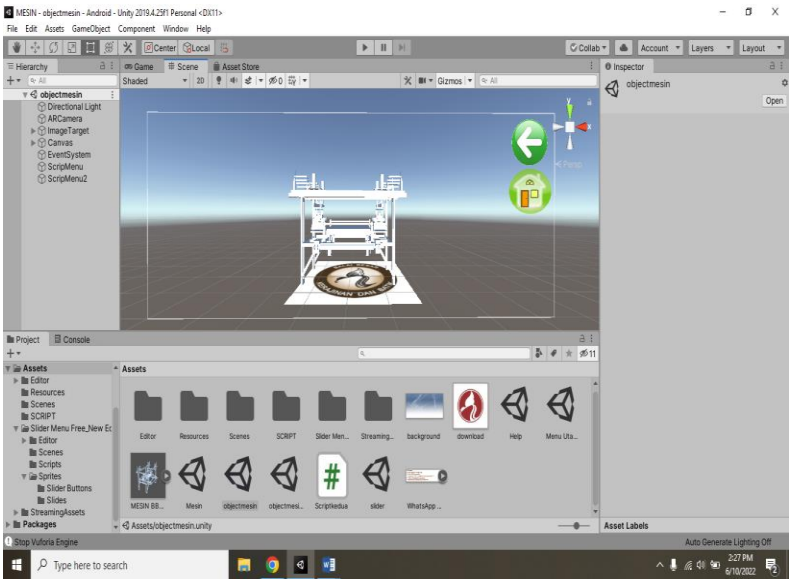

Figure 8. Scaning AR Page

Questionnaire Testing Results using User Acceptance Test

The following are the results of questionnaire testing using User Acceptance Test at the Center for Crafts and Batik:

Table 3. Use Acceptance Test Results

No	Question	Assessment				
		SA	A	N	D	SD
1.	Can the application be installed on a cellphone? Smartphone other	8	2			
2.	What is the appearance of the 3D shape on the batik cloth stamping machine good?	5	4	1		
3.	What is the application running well?	10				
4.	Does the button on the display of the batik cloth stamping machine work properly?	8	2			
5.	Does the application provide information about batik cloth stamping machines?	9	1			

No	Question	Assessment				
		SA	A	N	D	SD
6.	What is the Application easy to use	6	4			
7.	Does the application run smoothly	9	1			
8.	What is the menu in the application appropriate?	7	2	1		
9.	Can the menu you press run?	9	1			
10.	Does the camera's AR display work smoothly?	8	2			

Based on the questionnaire above regarding the appearance of the batik cloth stamping machine, the results :

Strongly Agree (SA) : 40
Agree (A) : 9
Netral (N) : 1
Disagree (D) : 0
Strongly Disagree (SD) : 0

After getting the results from the questionnaire that has been created, the next step is to calculate the results of the questionnaire by referring to the weights, percentage formula values and assessment standards using the method user acceptance test the calculation is as follows:

Table 4. Result Question 1-5

Information	Score	Frequency	S
SD	1	0	0
D	2	0	0
N	3	1	3
A	4	9	36
SA	5	40	200
Amount		50	239

$$P = \frac{239}{250}\ x\ 100\ \% \\ = 95{,}6\%$$

Based on the percentage value results in the table above, it can be concluded that the assessment of the question regarding whether respondents agree that the application that was built makes it easier to understand the redesign of the batik cloth stamping machine is 95.6% out of 100% which can be categorized as agreeing.

Then, based on the questionnaire above regarding the application menu display, the results obtained from questionnaire questions number 6 to 10 are as follows:

Strongly Agree (SA) : 39
Agree (A) : 10
Netral (N) : 1
Disagree (D) : 0
Strongly Disagree (SD) : 0

After getting the results from the questionnaire that has been created, the next step is to calculate the results of the questionnaire by referring to the weights, percentage formula values and assessment standards using the method user acceptance test the calculation is as follows:

Table 5. Result Question 6-10

Information	Score	Frequency	S
SD	1	0	0
D	2	0	0
N	3	1	1
S	4	10	40
SA	5	39	195
Jumlah		50	236

$$P = \frac{236}{250}\ x\ 100\ \%$$
$$= 94\%$$

Based on the results of the percentage value in the table above, it can be concluded that the assessment of the question regarding whether respondents agree if the application built makes it easier to understand information about the use of augmented reality visualization as a technology to view machine components in 3 dimensions, where this value is obtained at 94.4% of 100% which is included in the agree category.

CONCLUSION

Based on research conducted at the Center for Crafts and Batik, it can be concluded that the innovation of using Augmented Reality (AR) to visualize a 3D image of the batik cloth stamping machine has provided various benefits. One of the main advantages is the ability to visualize the machine in three-dimensional form, which enhances understanding and analysis of its design. From the results obtained using the user acceptance test method, the visualization of the batik cloth stamping machine received a score of 95.6%, and the application menu interface received a score of 94.4%. Therefore, the evaluation of the 3D model through AR visualization has proven to be effective, making it a valuable tool for assessing and providing suggestions for improvements to the batik stamping machine. Creating a 3D model before producing the machine physically enables better planning, reduces development costs, and increases overall efficiency

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