



## Hamming Code at Marker-Based Augmented Reality on the Android Platform for Teaching Philosophy of Batik

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### Abstract

Batik is one of the many cultural heritage of Indonesia that has high artistic value and has become the hallmark of a nation that must be preserved. Augmented reality (AR) is a technology that adds virtual objects into the real world. This technology could provide new ways of delivering information to users, a more interactive way. In this research, a system of marker-based AR tracking used the introduce batik was made. One type of augmented reality is AR marker-based tracking. To track markers, several there are steps that must be performed on every frame received from the camera android smartphone. Phase tracking in this study includes of conversion of images from the camera frame into a grayscale image, detects the contour, perspective transformations, and decoding algorithm using Hamming Code. Test-based results by author, tracking markers on this system could properly track 100% of each marker in normal circumstances, within a certain range depending on the size of the marker and at an angle of 45°. Test-based results by author, tracking markers on this system could properly track 100% of each marker in normal circumstances, within a certain range depending on the size of the marker and at an angle of 45°.

*Keywords:* Augmented reality, Tracking Marker, Android, Batik, Hamming Code

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### 1. Introduction

Batik is a fabric made with anti-wax dyeing techniques (hinder fabrics using wax that the certain parts are not affected by color). It is one of the many cultural heritages

of Indonesia which has high artistic value and has become a hallmark of the nation [1]. The determination of Indonesian batik as Cultural Heritage Humanity's Oral and Non-material (Masterpieces of the Oral and Intangible Heritage of Humanity) by UNESCO and the Republic of Indonesia Presidential Decree No. 33 of 2009 are confirmed as important to preserve the Indonesian batik. One way to preserve the culture is no other than to know it. To recognize batik, we can read it from a book or from an article on the internet, but it seems passive and static in the absence of direct interaction. One way to overcome these obstacles is to use computer technologies such as multimedia [2].

One of computer technology utility in the field of multimedia is Augmented Reality (AR). The augmented reality (AR) gives a new insight into various aspects of life and one of it is education. According to [3] AR is a technology in which virtual objects are added / projected onto a real-world environment in real-time (real-time). By combining virtual objects with real-world environment, AR provides a new experience in terms of computer and human interaction. With the help of AR, the user can interact with virtual objects that can make the delivery of information becomes more interactive and interesting.

The research in [4] stated that augmentation can be seen as a tool, not as an end. The real goal is to improve the perception and the interaction with the real world. AR system makes the real world as a basis and incorporates of some technologies by adding contextual data in the same place. The application of the AR concept is expected to increase the power of reason and imagination of a person, so that one can be better to understand it. According to the study in [5], the excess of the AR system as compared to a book or other data source media is the presented information presented in the same location as the original object. This makes the information more interesting and easier to understand. Based on the study, the Augmented Reality technology in learning has contribution in improving learning outcomes as compared to using a web-based media [6]. According to a similar study, the result is the students want to continue using AR technology in the future and they do not show anxiety when using AR technology [7]. In the other studies show that the understanding in training in the use of Augmented Reality is better than using another tools [8]. In addition, the AR can encourage motivation, comprehension and higher engagement with the learning contents [9]. A study about using a video lesson AR reveals that it can improve the efficiency of

learning held in a classroom [10]. The implementation of Augmented Reality in learning materials also can provide more information about the object being studied, information about the shape, texture, and more visualization to object [11].

According to the research in [12], AR technology was tested in the manufacture of a choreography. The result is the AR technology gives a sense of pleasure to users. In addition, the AR technology is more effective and efficient in the process of making choreography compared with using other applications on the computer device. The research in [13] uses AR technology as a navigation system to gain access to the peroneal artery retrograde to an 84-year-old woman with critical limb ischemia. The obtained result with the help of AR technology has the potential to affect access to the target vessel with a volume of contrast material and the radiation exposure is low compared to using conventional means. The study [14] stated that the AR technology is applied into the context of advertising and the result is that the advertising AR can improve consumer attitudes toward advertising through increasing their curiosity about the ad. In other studies from the research [15] with the game by integrating technology Mobile Augmented Reality (MAR) shows that the game is intrinsically satisfying for children and it can trigger positive emotions like enthusiasm, excitement, and curiosity that enhances the mood of the participants and it can help increase the level of engagement.

Therefore, the researchers use AR technology to teach the philosophy of batik to make it more attractive and interactive. In this study, the system will be built using the method of tracking marker (marker-based tracking) and the method of AR with tracking markers. The purpose of this study was to develop a software that can be used to introduce batik to provide a new experience in learning the motif by displaying information visualization philosophy on the particular pattern (Augmented Reality). In addition, this study was made to obtain the accuracy and performance value of the marking tracking system against marker distance, marker size, angle shooting, high availability, noise level, distortion and aspect ratio markers obtained from the experiments.

## 2. Methods

Batik is a textile fabric that has a variety of decorative/illustration. The batik surface is made with anti-wax dyeing technique (dyeing technique using wax or batik wax as a color barrier), and it is one of Indonesia's cultural heritages that has a national characteristic and high artistic value [1].

Indonesian batik patterns possessed design/motif as well as different models in each region that characterizes the area, as it is written in the book [16]. Diversity and changes to the public from time to time lead to the design pattern motif is present in diverse forms as well. Although it has evolved over time, this does not eliminate the characteristics of batik which has traditional values and has a deep philosophical meaning [17].

AR is a technology in which virtual objects / 3D virtual objects are integrated / projected onto a real-world environment in real-time [3]. By combining virtual objects with real-world environment, AR provides a new experience in terms of computer and human interaction. With the help of AR, the user can interact with virtual objects in real-time, so that they can make the delivery of information becomes more interactive and interesting. The purpose of the AR system is to combine the real world and the world generated by the computer, so that they appear as one entity [18].

The Marker-based AR tracking system, a marker that identifies the type AR, is usually black and white. In this method, the used markers have been identified in advance by the system. The marker will be the coordinate point that serves to determine the position of the virtual object that will be raised in the real environment. Position of the object will be just above the marker line with the Z-axis and perpendicular to the X-axis (right or left) and the Y-axis (front or rear). Markers will also determine the direction of rotation of the virtual object, as well as determining the virtual object / information to be displayed. Marker is the trigger that will be recognized by the camera. Good marker is a marker that is easily visible and reliable in any condition.

The study [19] stated marker bitonal (only two color) black and white combination is frequently used than other colors, not least because the process of tracking the marker will be easier because the search for the contrast is very clear, if it compared, it must

recognize the color of the marker is less clear that will ease decisions during the process of floating (thresholding).

According to the research [20] a marker must be at least four different angles point to be used to calculate the position. Generally shaped marker has a quadrilateral-shaped frame outline (polygon have four sides and four vertices or corners formed from the ends of the interconnected), and all four edges of the used corner to estimate the 3D pose.

One of the researches related to the detection of the distance markers is the research in [19] that the test detection marker between distance and rotation markers and markers show the results of these studies can be detected up to a distance of 330 cm by using a marker template. In addition, the research is also carried out to detect the marker [21], but markers can only be detected up to a distance of 50 cm. Other research on marker testing using several types of markers conducted by the study [22], all markers tested a marker template (having a black frame, white background, and the image marker in the center with black color) with different levels of complexity, the results of the study show that the detection of markers can be detected up to a distance: 212 cm, 57 cm, 82 cm for category of simple, medium and complex. Further research from the study [23] shows that the marker can be detected up to 210 cm.

Adding a pattern in a black frame can be added for distinguishing between markers with each other markers. The success program in detecting ID on a marker becomes an important matter, because the program will display an object based on the ID contained in the marker. Marker pattern is usually kept simple, but still unique.

Hamming code is one kind of mistake detection method (error correction) which is most widely used. The key to this method is to insert a few pieces of parity bits (parity bits) into the data to detect any errors. The parity bits are inserted depending on the length of the data. The parity bits are inserted into the data can be calculated like this (see **Eq.1**):

$$\begin{aligned} m &= 2n \\ p &= n + 1 \end{aligned} \tag{1}$$

Where  $m$  = the number of bits of data, and the  $p$  number of parity bits. Example: If the data bits = 8 bits, then  $8 = 2^3$ . So the parity bits consists of  $3 + 1 = 4$ . **Table 1** shows increasing bits and parity bits.

**Table 1.** *The increase in data and parity bits.*

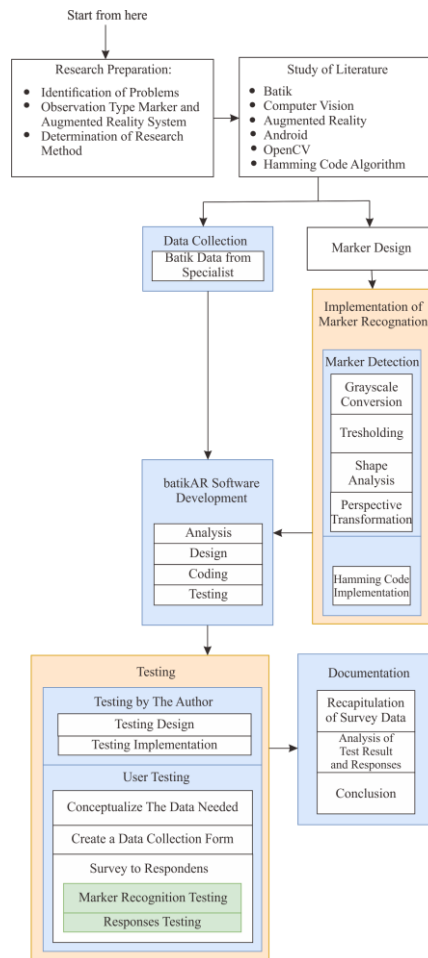
| bit Data | bit Parity |
|----------|------------|
| 2        | 1          |
| 4        | 2          |
| 6        | 3          |
| 8        | 4          |
| 16       | 5          |
| 32       | 6          |
| 64       | 7          |
| 128      | 8          |

There are few rules in Hamming Code, including:

- Position bits Hamming expressed in  $2^n$  with  $n$  integers so that the bits of Hamming will be in positions 1, 2, 4, 8, 16, and so on.
- Other positions filled by bits that will be encoded. (Position 3, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 17, and so on).
- Each parity bit calculates the parity for some of the bits in the code word. The position of the parity bit determines the sequence of bits that alternately check and pass.
  - Position 1: check 1 bit, skip 1 bit, check one bit, skip 1 bit, and so on. (1,3,5,7,9,11,13,15, ...)
  - Position 2: check out 2 bits, skipping two bits, check 2 bits, skipping two bits, and so on. (2,3,6,7,10,11,14,15, ...)
  - Position 4: check out 4 bits, 4 bits missed, check 4 bits, 4 bits skipped, and so on. (4,5,6,7,12,13,14,15,20,21,22,23, ...)
  - Position 8: check the 8-bit, 8-bit jump, check out 8 bit, jumped 8 bits, and so on. (8-15,24-31,40-47, ...)
  - Position 16: check 16 bit, 16 bit jump, check out the 16-bit, 16-bit jump, and so on. (16-31,48-63,80-95, ...)
  - Position 32: check out 32 bits, 32 bits jump, check out the 32-bit, 32-bit jump, and so on. (32-63,96-127,160-191, ...)

- Set the parity bit to 1 if the total number of bits examined odd. Setting a parity bit to 0 if the total number of bits is checked even.

The research design conducted is as illustrated in **Figure 1**. Moreover, the explanation is as follows:



**Figure 1.** Research design.

## 2.1 Data collection

To conduct this study, the authors conducted data collection batik from batik expert at University of Indonesia. The data obtained through direct interviews.

Cimahi is one of the new areas in developing batik. Motif appointed by the wealth that exist around the city of Cimahi. Five motif that has been agreed by the government of Cimahi city to become the cultural identity of the city of Cimahi, including: Pusdik motif (see **Figure 3**), Bamboo Ciawitali motif (see **Figure 2**), Cirendeu motif, Kujang motif (see **Figure 5**), Curug Cimahi motif (see **Figure 4**). Here are a few examples of the philosophy of batik Cimahi:



*Figure 2. Batik motif of bambu Ciawitali.*

Ciawitali, the name of a village in the district of Cimahi middle, is overgrown clump of bamboo with typical sized trunk, which is rather small and flexible, so it can be used for purposes of rigging. Sundanese people call it Awi rope. **Table 2** shows the characteristics and philosophy of the bambu motif Ciawitali.

**Table 2.** *Characteristics and Philosophy Batik Bambu Ciawitali.*

| Characteristics   | Philosophy  |
|---|---|
| <ul style="list-style-type: none"> <li>The type of grass plants can grow very high yet.</li> </ul>                      | <ul style="list-style-type: none"> <li>Background not be important, but how one is able to seek to express their potential so as to have its own character.</li> </ul>                  |
| <ul style="list-style-type: none"> <li>Has strong roots.</li> </ul>   | <ul style="list-style-type: none"> <li>There are times when temptations and trials come in life, therefore it is important to form a strong foundation in order to be ready.</li> </ul> |
| <ul style="list-style-type: none"> <li>Bamboo growth cycle is very long before. it becomes a powerful plant.</li> </ul> | <ul style="list-style-type: none"> <li>Life is a process. Through with patience, persistence, and perseverance so that later can be an aspire.</li> </ul>                               |
| <ul style="list-style-type: none"> <li>Versatile plant.</li> </ul>  | <ul style="list-style-type: none"> <li>Trying to be able to provide the maximum benefit to the surrounding environment.</li> </ul>  |
| <ul style="list-style-type: none"> <li>Strong yet supple (flexible).</li> </ul>   | <ul style="list-style-type: none"> <li>Flexibility bamboo teaches us to be adaptable and easy to set up but remains firm on the establishment (strong but not rigid).</li> </ul>        |





**Figure 3.** *Batik motif of Pusdik.*

Cimahi is famous with the soldiers because of the large military training center in the city of Cimahi. Although relatively small city, it reaches a dozen Pusdik that distinguishing Cimahi city with other cities in West Java. In Pusdik motif, it painted various educational activities such as military combat training, Candradimuka crater motif that is a symbol of military education, and others. **Table 3** shows the characteristics and philosophy of motives Pusdik.

**Table 3.** *Characteristics and Philosophy of Batik Pusdik.*

| <b>Characteristics</b>   | <b>Philosophy</b>   |
|--|---|
| Pusdik motifs painted on military activities such as: <ul style="list-style-type: none"> <li>• Grenades</li> <li>• Missile</li> <li>• Pistol</li> <li>• Bullets</li> <li>• Tank steel</li> </ul> | Batik Pusdik contains the values of philosophy: <ul style="list-style-type: none"> <li>• Struggle</li> <li>• Solidarity</li> <li>• Persistence</li> <li>• Discipline</li> </ul> |



**Figure 4.** *Batik motif of Curug Cimahi.*

Curug Cimahi is the name of the waterfall. This motif was chosen as an expression of gratitude to God for a way confers natural conditions beautifully. **Table 4** shows the characteristics and philosophy of the curug cimahi motif.

**Table 4.** *Characteristics and Philosophy of Batik Curug Cimahi.*

| <b>Characteristics</b>   | <b>Philosophy</b>  |
|--|--|
| <ul style="list-style-type: none"> <li>• Flowing from high places to low places.</li> <li>• Flowing endlessly though along a steep road and rocks.</li> <li>• Soothing &amp; Cooling.</li> </ul> | <ul style="list-style-type: none"> <li>• Teach people to always give thanks to God.</li> <li>• Raise the geographical potential of nature that is around Cimahi.</li> <li>• Being personally reconcile at every opportunity.</li> <li>• Undeterred obstacles in order to achieve the goal.</li> <li>• Katika share price or increase knowledge and be of benefit to others.</li> </ul> |



**Figure 5.** *Batik motif of Kujang.*

Kujang known as traditional western Java object that has a sacred value and believed possessed magical powers. **Table 5** shows the characteristics and philosophy of motives clever.

*Table 5. Characteristics and Philosophy of Batik Kujang.*

| <b>Characteristics</b>   | <b>Philosophy</b>  |
|--|--|
| <ul style="list-style-type: none"><li>• Has a sharp edge.</li></ul>                                      | <ul style="list-style-type: none"><li>• Reflecting Sharpness is of critical power in life.</li></ul>   |
| <ul style="list-style-type: none"><li>• Kujang material tends to thin.</li></ul>                         | <ul style="list-style-type: none"><li>• Preserving traditional Javanese heirlooms west through documentation in the form of the motif.</li></ul> |
| <ul style="list-style-type: none"><li>• The material is dried.</li></ul>                                 | <ul style="list-style-type: none"><li>• Symbolizes strength and courage to protect our rights and the truth.</li></ul>                           |
| <ul style="list-style-type: none"><li>• Porous and contains a lot of metal elements of nature.</li></ul> |  |

## 2.2 Design of Experiments

Before conducting experiments on this research, the authors should specify experimental design about what will be done, other than that the author must also set the current light environment experiment, so when the testing of the tracking markers can run well, without any objects or shadows blocking.

Experiments conducted by the authors to measure the performance of the AR system is created, the experiment was also performed using the same device. To measure the performance of the system, the author has formulated several parameters of the experiment to be carried out, including:

- Time recording, this experiment is carried out by utilizing the logcat function on the IDE eclipse. By adding the command log, the source code android writer can make record time before and after the process is done. Logcat function can run in milliseconds as to make more accurate recording. The recorded processes are: receives the catch of the frame, before and after the function thresholding, before and after detecting the contour, before and after the selection of the size of the polygon, before and after the selection of the angle polygon, before and after the transformation function perspective, before and after validation of the marker, and the time needed to display the visualization starts from the image capture process.
- Marker tracking accuracy, this experiment is done by using several markers that have been made previously, to quantify the level of accuracy.

Calculation of the accuracy of the tracking success measured by the number on the marker used. Experiments carried out by using 50 unique markers (markers that different between one and the other).

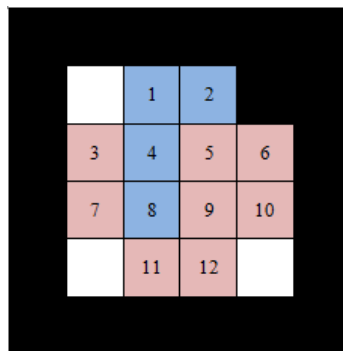
- Tracking markers and markers to measure the distance shooting, this experiment was conducted to measure how far the maximum and minimum of a marker can be traced to a specific size. Experiments carried out by measuring markers of 1-10 cm and a distance of 10-100 cm.
- The tracking of the marker with the level of visibility (black) specific. This experiment was conducted to measure the level of black marker on a white background that they can be tracked by the system. Experiments carried out with the visibility level of 10%, 20%, 40%, 60% and 80%.
- The tracking of the shooting angle. This experiment was conducted to determine the maximum and minimum distance markers can be detected at an angle of 450.
- The tracking of the marker with the level of noise. This experiment was conducted to determine whether the system can detect a marker with a specific noise situation. Experiments carried out on the marker with a noise level of 25%, 50%, 75%, and 100%.
- Tracking markers with certain aspect ratios, this experiment was conducted to find out whether markers can still be tracked with certain aspect ratios. Experiments were performed on markers with aspect ratio  $\frac{1}{3} H, \frac{1}{2} H, \frac{2}{3} H, \frac{1}{3} V, \frac{1}{2} V, \frac{2}{3} V$ , where H = Horizontal and V = Vertical.
- The tracking of the markers are covered. The experiments were done by covering part of the marker, to determine whether the system can still detect a marker if there are covered areas.

### 3. Results and Discussion

#### 3.1 System Design Batik AR to teach philosophy

The first stage in the design of AR system is to make the design of the marker, because the AR system to be constructed using the method of tracking markers, in the other words, the authors make the design of the design markers that will be recognized by the system, therefore this process is done before the design of systems for created. After conducting observations of types of augmented reality markers and framework, researchers decided to use a simple binary marker design. Besides evident from several studies that the marker bitonal (black and white combination), it will be more easily identified when it compared with a marker using a specific color, this marker also already meet the minimum specs of a marker disclosed [20].

Binary marker consists of 6x6 boxes with the same size, with a solid black frame. Inside, there are 4 boxes/cells used for code orientation and 12 boxes for identification markers. Orientation code is in between the corners, given a white color except in the upper right corner, which is black. Id identification and correction of errors in the signing is done by using Hamming Code. There are 12 boxes for the identification of markers, 4 of which are used for parity bits. This means that with this design, researchers can create a unique marker  $2^8 = 256$ .



*Figure 6. Design marker.*

From **Figure 6** visible marker has a color that varies, but the marker is actually black and white. There are 4 corner boxes are used as a reference part in rotation, three are white and one black box. There are 4 represent the blue box to the parity bit, and 8 boxes of pink remainder represent bits of data.

Visualization features covers the process of tracking markers using OpenCV. Tracking markers on this application is basically done by examining every frame received from the camera. After receiving the frame of the camera is done by tracking the marker (conversion of grayscale, thresholding, contour detection / analysis of the shape, and perspective transformation), the candidate markers and marker validation proceed to read its value. The results of this process will generate data bits of markers that can be identified, and modified bit sequence/position by rotation. Having obtained a valid data bits, the data bits are then decoded to produce the id of the marker then compared (matched) with the existing data in the database, if the id matches, the visualization will be displayed.

Furthermore, there is a feature update including downloading data on the database server. In this process, the authors must create another program that can be connected directly to the database on the server to perform batik data management. The management process is referred to the CRUD process (Create, Read, Update, and Delete). The database contains information on id marker and batik information (description, characteristics, and philosophy) that will be displayed on the mobile phone screen when the application recognizes id marker. The output in server applications is such as JSON file, so it will be easy to batikAR application parses data from the server. For more details about this application, it will be explained in the next section about interface design.

### 3.2 Design Interface Design

BatikAR application is made for smartphones with Android operating system. There are 5 pre-designed interface which display a launcher, games, info, ask, and updates. The launcher or the main page is shown in **Figure 7**.



**Figure 7.** Implementation of views batikAR.

**Figure 7** is some interfaces of the batik AR application. There are titles, as well as some of the key to the usefulness of each: 1) Start, to start the program AR. 2) Download the data to download or update the data from the server and stores the data from the server to the database application. 3) Ask, for displaying instructions batikAR application usage. 4) Information, to display the description information of the application batikAR. Then, there is a user interface display applications usage (middle), starting with the button pressed to sample a marker that can be recognized by the program. There is no much different from the interface description view with description of information system (right) which contains information about the application as well as those involved in manufacture batikAR application. Both use an HTML file.

### 3.3 Simulation Results

After conducting experiments, the authors noted the results of the various experiments that have been done, until further data from experiments can be used to make a conclusion.

The first experiment is an experiment in the recording time of each process. This experiment was conducted to measure the time to search the marker and to display a visualization of the phone screen. The experiments were done using logcat feature in Eclipse, this feature allows the Eclipse keeps a log of the running system in units of millisecond/milliseconds. To calculate the time in each process, the authors save the command code for sending the log, before and after the process. The recorded processes are including initial camera catches process, before and after threshold process, before and after contour detection process, before and after the selection contour size before and after selected number of angles, before and after the transformation process perspective.

**Table 6** shows the result of recording the time required in each process performed by the system. Based on 10 times the recording, do the calculations for finding the average time. **Table 7** shows the difference in every process that occurs in the system with units of seconds. An empty cell in the selection angle iteration calculation, perspective transformation, and marker validation occur because of the loop calculation on contour list.

The second experiment is an experiment marker recognition accuracy. This experiment was conducted to test the accuracy of the system in recognizing the marker. Experiments are performed by the tracking of the 50 markers that were conducted alternately. Tracking carried out repeatedly to ensure for getting good results. The 50 markers were used and all of that markers can be recognized by both / right (Picture of markers that are used can be found in the appendices section).

The third experiment is an experiment to spacing and sizing the marker. This experiment was conducted to examine the effect of the shooting distance and the size of the tracking system of the AR marker made. The Experiments used a marker with the size of 1 cm – 10 cm range shooting distance of 10 cm – 100 cm.



Experiments carried out by two people, one to do the shooting and the other to record the distance and others. Checks carried out repeatedly on each marker to make sure to get results as accurate as possible, at least 3 times the decision, if it is enough, then the results are recorded. Measurements were made using a tool made themselves so that the measurement process becomes easy. Sometimes testers must move the position marker lights to be recognized.

From the results of experiments on the size of the marker and shooting distance, it can be concluded that for each increasing in marker size of 1 cm, the maximum distance for markers to pick up will be 10 cm. Markers with a size of 6 cm and larger cannot be detected at the distance of 10 cm, because the size of the marker is too big, so that no part of the marker can cause severed.

The fourth experiment is an experiment to visibility (black) marker. This experiment was conducted to measure the performance of the tracking of the markers that have visibility/specific blackish. To create a bookmark with a certain visibility, the marker is made with the help of photoshop program. Experiments carried out on the marker with the level of visibility of 80%, 60%, 40%, 20% and 10%

**Table 6. Result Timekeeping.**

| <b>No.</b> | <b>camera catches</b> | <b>early threshold ing</b> | <b>end threshold ing</b> | <b>Early contours detection</b> | <b>End of contour detection</b> | <b>Initial contour size</b> | <b>End of contour size</b> | <b>Initial contour corner</b> | <b>End contour corner</b> | <b>Early transfor mation</b> | <b>End transfor mation</b> | <b>Early validation</b> | <b>End validation</b> | <b>Pop visualizat ion</b> |
|------------|-----------------------|----------------------------|--------------------------|---------------------------------|---------------------------------|-----------------------------|----------------------------|-------------------------------|---------------------------|------------------------------|----------------------------|-------------------------|-----------------------|---------------------------|
| 1          | 42 508                | 42 528                     | 42 588                   | 42 588                          | 42 618                          | 42 618                      | 42 618                     | 42 618                        | 42 628                    | 42 628                       | 42 628                     | 42 628                  | 42 628                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 42 638                        | 42 638                    | 42 638                       | 42 638                     | 42 638                  | 42 648                |                           |
| 2          | 42 718                | 42 738                     | 42 788                   | 42 788                          | 42 838                          | 42 838                      | 42 848                     | 42 688                        | 42 698                    | 42 698                       | 42 698                     | 42 698                  | 42 698                | 42 708                    |
|            |                       |                            |                          |                                 |                                 |                             |                            | 42 848                        | 42 848                    | 42 848                       | 42 848                     | 42 848                  | 42 848                |                           |
| 3          | 42 878                | 42 898                     | 42 948                   | 42 948                          | 42 988                          | 42 988                      | 42 988                     | 42 848                        | 42 848                    | 42 848                       | 42 858                     | 42 858                  | 42 858                | 42 868                    |
|            |                       |                            |                          |                                 |                                 |                             |                            | 42 988                        | 42 988                    | 42 988                       | 42 988                     | 42 988                  | 42 988                |                           |
| 4          | 43 048                | 43 058                     | 43 108                   | 43 108                          | 43 159                          | 43 159                      | 43 159                     | 42 988                        | 42 988                    | 42 988                       | 43 008                     | 43 008                  | 43 008                | 43 038                    |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 008                        | 43 018                    | 43 018                       | 43 018                     | 43 018                  | 43 018                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 159                        | 43 159                    | 43 159                       | 43 159                     | 43 159                  | 43 169                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 169                        | 43 169                    | 43 169                       | 43 169                     | 43 169                  | 43 169                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 179                        | 43 179                    | 43 179                       | 43 179                     | 43 179                  | 43 179                | 43 189                    |
| 5          | 43 199                | 43 219                     | 43 219                   | 43 219                          | 43 369                          | 43 369                      | 43 379                     | 43 379                        | 43 379                    | 43 379                       | 43 379                     | 43 379                  | 43 389                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 389                        | 43 399                    | 43 399                       | 43 409                     | 43 409                  | 43 409                | 43 419                    |
| 6          | 43 429                | 43 459                     | 43 459                   | 43 459                          | 43 559                          | 43 559                      | 43 559                     | 43 559                        | 43 559                    | 43 559                       | 43 559                     | 43 559                  | 43 559                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 559                        | 43 559                    | 43 569                       | 43 569                     | 43 569                  | 43 569                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 569                        | 43 579                    | 43 579                       | 43 579                     | 43 579                  | 43 579                | 43 589                    |
| 7          | 43 599                | 43 609                     | 43 689                   | 43 689                          | 43 729                          | 43 729                      | 43 729                     | 43 729                        | 43 729                    | 43 729                       | 43 729                     | 43 729                  | 43 739                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 739                        | 43 739                    | 43 739                       | 43 739                     | 43 739                  | 43 749                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 759                        | 43 759                    | 43 759                       | 43 759                     | 43 759                  | 43 759                | 43 769                    |
| 8          | 43 779                | 43 789                     | 43 859                   | 43 859                          | 43 859                          | 43 899                      | 43 899                     | 43 909                        | 43 929                    | 43 929                       | 43 929                     | 43 929                  | 43 939                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 43 949                        | 43 949                    | 43 949                       | 43 949                     | 43 949                  | 43 989                | 44 019                    |
| 9          | 44 059                | 44 069                     | 44 129                   | 44 129                          | 44 170                          | 44 170                      | 44 180                     | 44 180                        | 44 180                    | 44 180                       | 44 180                     | 44 180                  | 44 190                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 44 190                        | 44 190                    | 44 190                       | 44 190                     | 44 190                  | 44,200                | 44 220                    |
| 10         | 44 230                | 44 250                     | 44,300                   | 44,300                          | 44 340                          | 44 340                      | 44 350                     | 44 350                        | 44 350                    | 44 350                       | 44 350                     | 44 350                  | 44 360                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 44 360                        | 44 360                    | 44 360                       | 44 360                     | 44 360                  | 44 360                |                           |
|            |                       |                            |                          |                                 |                                 |                             |                            | 44 360                        | 44 360                    | 44 360                       | 44 360                     | 44 360                  | 44 370                | 44 380                    |

*Table 7. Experimental Results Of Timekeeping.*

| No.            | Threshold | Contour detection | Selection Size | Angle Selection   | Transformation Perspective | Marker Validation    | Bring up the visualization |
|----------------|-----------|-------------------|----------------|-------------------|----------------------------|----------------------|----------------------------|
| 1              | 0:06      | 0:03              | 0              | 0:01<br>0<br>0:01 | 0<br>0<br>0                | 0<br>0:01<br>0       | 0.2                        |
| 2              | 0:05      | 0:05              | 0:01           | 0<br>0<br>0:01    | 0<br>0:01<br>0             | 0<br>0<br>0          | 0:15                       |
| 3              | 0:05      | 0:04              | 0              | 0<br>0<br>0:01    | 0<br>0:02<br>0             | 0<br>0<br>0          | 0:16                       |
| 4              | 0:05      | 0051              | 0              | 0<br>0<br>0:01    | 0<br>0<br>0                | 0:01<br>0<br>0       | 0141                       |
| 5              | 0:05      | 0.1               | 0:01           | 0<br>0:01         | 0<br>0:01                  | 0:01<br>0            | 0:22                       |
| 6              | 0:05      | 0:05              | 0              | 0<br>0<br>0:01    | 0<br>0<br>0                | 0<br>0<br>0          | 0:16                       |
| 7              | 0:08      | 0:04              | 0              | 0<br>0<br>0       | 0<br>0<br>0                | 0:01<br>0:01<br>0    | 0:17                       |
| 8              | 0:07      | 0:04              | 0:01           | 0:02<br>0<br>0    | 0<br>0<br>0                | 0:01<br>0:04<br>0:01 | 0:24                       |
| 9              | 0:06      | 0041              | 0:01           | 0<br>0            | 0<br>0                     | 0:01<br>0:01         | 0161                       |
| 10             | 0:05      | 0:04              | 0:01           | 0<br>0<br>0:01    | 0<br>0<br>0                | 0:01<br>0<br>0       | 0:15                       |
| <b>Amount</b>  | 0:57      | 0482              | 0:05           | 0:09              | 0:04                       | 0:13                 | 1,752                      |
| <b>Average</b> | 0057      | 0048              | 0005           | 0003              | 0002                       | 0005                 | 0175                       |

**Table 8.** The results of the experiment the level of visibility / black.

| Distance<br>Marker Size | Visibility Level |     |     |     |     |
|-------------------------|------------------|-----|-----|-----|-----|
|                         | 10%              | 20% | 40% | 60% | 80% |
| 1 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 2 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 3 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 4 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 5 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 6 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 7 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 8 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 9 cm                    | ✗                | ✗   | ✓   | ✓   | ✓   |
| 10 cm                   | ✗                | ✗   | ✓   | ✓   | ✓   |

Information:

✓ = Marker can be identified

✗ = Marker unrecognized / misidentified

The experiments that carried out by the state of the light were good, and the marker is placed on a white paper (HVS). Table 4.3 shows the experiment results of tracking the level of visibility/black markers that show similar results when an experiment conducted on the visibility of 80% to 40% visibility, but the marker cannot be recognized on the availability of 20% and below. The experiments were also conducted with markers made using 2B pencil but the marker is not detected.

The fifth experiment is an experiment on the shooting angle. This experiment was conducted to measure the tracking system of the shooting angle, the experiments were carried out of the corner 45° of the bottom, right, left, and top of the marker. The maximum distance markers can be identified at an angle of 45°.

Based on the experimental results table 4.4 of the decision-markers with 45° angle, either from the top, bottom, right and left, it reduces the maximum distance marker tracking. The reduction of the maximum distance can be greater than the tracking markers on the marker with a large size.

The sixth experiment is an experiment on the level of noise in the marker. This experiment was conducted on the marker with a noise level of 25% -100%, this marker is made with the help of photoshop program which has the feature to add noise to an image. The experiments carried out such experiments on the distance and the size of

the marker. Based on the experiments, the results are still identifiable markers although the marker has a noise level of 100%.

**Table 9.** *The results of experiments on the corner of 45°.*

| Corner Size<br>Bookmark | 45° right | 45° left | 45° on | Under 45° |
|-------------------------|-----------|----------|--------|-----------|
| 1 cm                    | 6 cm      | 7 cm     | 7 cm   | 7 cm      |
| 2 cm                    | 17 cm     | 16 cm    | 17 cm  | 20 cm     |
| 3 cm                    | 25 cm     | 26 cm    | 25 cm  | 28 cm     |
| 4 cm                    | 35 cm     | 33 cm    | 34 cm  | 37 cm     |
| 5 cm                    | 42 cm     | 41 cm    | 40 cm  | 45 cm     |
| 6 cm                    | 50 cm     | 51 cm    | 49 cm  | 52 cm     |
| 7 cm                    | 59 cm     | 59 cm    | 61 cm  | 60 cm     |
| 8 cm                    | 68 cm     | 68 cm    | 66 cm  | 71 cm     |
| 9 cm                    | 76 cm     | 75 cm    | 75 cm  | 76 cm     |
| 10 cm                   | 81 cm     | 80 cm    | 82 Cm  | 83 cm     |

The further experiments are on the aspect ratio of the marker. The experiments are using a marker with a size of 4 cm. The following table of the experiments results on the aspect ratio of the marker:

**Table 10.** *Results of experiments with an aspect ratio.*

| Size | 1/3 H | 1/2 H | 2/3 H | 1/3 V | 1/2 V | 2/3 V |
|------|-------|-------|-------|-------|-------|-------|
| 4 cm | 27 cm | 30 cm | 35 cm | 27 cm | 31 cm | 35 cm |

**Table 10** shows that the aspect ratio of the marker affects the maximum distance of tracking markers. Last experiment conducted to bookmark blocked/distorted. Based on the experiments, it is known that the marker is still identifiable if only eclipsed in the frame alone. Bookmarks cannot be recognized if the inside of the marker is blocked.

### 3.4 Discussion

From the experiment results of the recording time with 10 attempts, obtained some conclusions are:

- a. Thresholding process on average takes about 0.057 seconds.

- b. Contour detection process on average takes about 0.048 seconds
- c. The selection process polygon size on average takes about 0.005 seconds.
- d. The selection process polygon size on average takes about 0.005 seconds.
- e. Transformation process perspective takes an average of about 0.002 seconds.
- f. Marker validation process on average takes about 0.005 seconds
- g. To view a visualization, starting from the image capture process on average takes about 0.175 seconds.

From the experimental results of the accuracy of marker recognition, the percentages of the system calculation reveals that the augmented reality marker batikAR are recognized with a very high success rate, especially under normal circumstances and the lighting sufficient without any blocking, the markers can be recognized 100% by the system properly.

Based on the experiments to measure markers and distance shooting, it is known that the size of the markers affect the minimum and maximum distance markers that can be recognized by the system. Further, increasing the size of the marker by 1 cm, the maximum distance tracking markers add approximately 10 cm.

Based on the experiments visibility / blackish known, under the black marker is still identifiable marker when black levels over 20%, while the marker with less than 20% availability cannot be tracked by the system. Similarly, the markers are made using 2B pencil, these markers cannot be recognized by the system batikAR. Meanwhile, based on the experimental results of the noise level on the marker, it can be seen that the noise level does not cause a significant change. The markers are still recognizable despite the noise levels up to 100%.

Based on the experiments with camera angles, it is known that they can influence the maximum distance markers that can be identified. Markers can still be identifiable, retrieval is done from the bottom, top, right, and left. Reduction of the maximum distance shooting is directly proportional to the size of the markers, the large size of the marker, the greater the reduction in the maximum distance markers can be identified if the decision made at an angle of  $45^{\circ}$ . Based on the results of the experiments on the aspect ratio on the marker, it also found that the aspect ratio affects the maximum distance of a marker that can be recognized.

Last experiment is an experiment with a distorted markers, i.e. markers which closed at the time of shooting. Based on the results of this experiment, it can be seen that if the marker is still identifiable, the marker section covered only part of the black frame only. However, when it enters the inside of the marker, the marker cannot be recognized by the system.

#### **4. Conclusions**

Here is the conclusion of the implementation of Android-based Augmented Reality technology to teach the philosophy of batik:

1. Augmented reality applications on search-based marker batikAR use software library OpenCV and Algorithms Hamming Code, it can be done with the following approach: the conversion of the input image from the camera into a grayscale image, tresholding for segmentation/separate objects and background, the detection of the contour/shape analysis to look for possible markers with analyzing the shape of the image, to change the perspective of the transformation of image captures to be decoded and decoding to translate id.
2. Based on the test results by the authors, batikAR system can recognize the marker exactly 100%, over the markers have the availability of more than 20%, copying the noise on the marker does not affect at all on the marker recognition process. The addition of the marker size affects the maximum distance markers can be identified. The larger the marker, the more distant markers can be identified. The angle of the markers and aspect ratio will affect the maximum distance markers that can be identified. The marker will also still be recognized during the marker-covered part, but limited to the part of the frame only. The lighting greatly affects the detection of the marker.

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