Augmented Reality-Marker Detection Measurement on Heroes of Surabaya Mobile Games

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Abstract. — Different arrangement in selling freemium programming application is the In-App Purchase (IAP) technique, where clients can download and enjoy the application for free; however, there are premium highlights that must be paid. We use Augmented Reality (AR) innovation into the IAP framework in the buying system of the game application, Heroes of Surabaya (HOS). The application allows user keeps run and play on the Android mobile system, but it will require AR marker cards to enable the premium feature on it. This investigation plans to test the effectiveness of AR marker cards that proposed as a substitute for computerized cash on the purchasing system of the game application. From the experimental results, the distance of the marker and the light factor are the main factors for the success-rate of the detection of the AR marker.

1. Introduction
Mobile application developers use various ways to get revenue through applications that they market in online markets, such as In-Application Ads, Freemium, Paid Applications, IAP, Paywalls, and Sponsorship [1] - [3]. In online mobile game applications, the in-app purchase system (IAP) is believed to be more effective in attracting consumers than existing payment methods. Several studies on trends in user buying behavior indicate that IAP and Freemium are compared with initial payments [4] - [7]. When application developers use methods in applications, there are developers who will get more frequently from one user. Unlike applications for applications that get one-time revenue from one user for each application, they have been sold. Through IAP, game developers Along with the rapid development of mobile application technology, various applications have emerged in various ways to market it. Likewise, in online mobile game applications it is possible to get recurring income, through additional features offered.

To improve user experience and provide alternative payment media solutions for the IAP system. Based on several studies show that AR has a better market share than virtual reality. AR applications for fields called aCommerce are the second most popular in AR applications [8] - [10].

We make AR implementations for IAP systems based on paper markers. This is to buy premium items and will be applied in mobile games as an innovative and interesting method. Furthermore, we have arranged this article to be a part of materials and methods, experimental results and analysis, and conclusions.

HOS mobile game is inspired by war events in order to maintain Indonesia's independence, which occurred at Jembatan Merah Surabaya, on November 10, 1945. HOS mobile game runs on Android platform. This game tries to implement the IAP and AR systems on the purchasing system.
In-App Purchase (IAP) refers to a selling digital products from a mobile application, in the form of goods and services to users of the app [2]. This is another way to get profitability from software that can be sold at a low price or even free.

Augmented Reality (AR) is a technology that allows the immersion of virtual world into the real world. This technology has interactive and real-time properties. Through the identification of markers, 3D objects will appear in the real world [12].

The marker refers a pattern made in the form of images that will later be recognized by camera. Marker patterns can be made with graphic programs which are available. For standard markers, patterns are recognized is a marker pattern with a square shape with a box black in it [10].

2. Material And Method

2.1. Marker design

The markers concept are used in HOS mobile game AR Shop is a marker not only colored black and white, but in the form of a card that can collected by players. Customized marker image with the content in it with hope do not confuse players when wearing markers on in purchasing items. The marker was also given an explanation of the content it’s in it so that it can be more informative and useful. The marker shape will be shaped like on Fig.1.

![Figure 1. Design of card-AR-marker adopted from historical weapon of Indonesian people](image1)

![Figure 2. The implementation of example card AR-marker for modern weapon](image2)

2.2. The AR-Marker Implementation

The marker or the so-called target image used in the Augmented Reality Shop application is a picture of weapons cards and items created using image editing software. In this application we develop 13 weapons card markers and items. The image on the card is likened to weapons and items which will appear on the game, as shown in Fig.2.

The AR-marker then uploaded to the Vuforia Developer website https://developer.VUFORIA.com/targetmanager and entered in one database. The file has been uploaded and then assessed for quality by the system from Vuforia as in Fig. 3.

![Figure 3. Detection process on Vuforia framework. The accepted marker will be used as physical marker card. The digital identifier then saved in the marker database.](image3)
Fig. 3. shows that the uploaded marker was got five stars from Vuforia. The more stars, the better the detection process. The marker has been uploaded and then downloaded in format. unitypackage so that it can be read and exported to UNITY software. The uploader must be downloaded back to be included in the AR project. Markers can be downloaded on the same site when uploading it, and select UNITY editor as an option on the select platform.

3. Experiment Result and Analysis

3.1. Marker detection test

Test markers aim to find out the accuracy of the Augmented Reality application inside detect markers with 10 attempts on various conditions and situations that have been determined on this test. For testing this marker Initial edited using an editing application online picture https://pixlr.com/editor/ So that produce 12 different markers with effects that have been added from the original marker, as in fig.4

![Marker detection test](image)

Figure 4. Different experiment applied on the AR-marker.

Test results of successfulness marker detection with the normal and bright light condition, can be seen on Table 1.

Table 1. Experimental test results in bright light conditions.

| Image Mode   | Bright-Light Percentage | Test Results | Low Light Percentage | Test Results |
|--------------|-------------------------|--------------|----------------------|--------------|
| X-ray        | 0%                      | Not detected | 0%                   | Not detected |
| Black & White| 100%                    | Detected     | 100%                 | Detected     |
| Pastel       | 100%                    | Detected     | 0%                   | Not detected |
| Blur Pixel   | 100%                    | Detected     | 100%                 | Detected     |
| Comic        | 100%                    | Detected     | 100%                 | Detected     |
| Vignette     | 100%                    | Detected     | 100%                 | Detected     |
| Glow         | 100%                    | Detected     | 100%                 | Detected     |
| Old Poster   | 100%                    | Detected     | 100%                 | Detected     |
| Inverse      | 100%                    | Detected     | 0%                   | Not detected |
| Old Pastel   | 100%                    | Detected     | 0%                   | Not detected |
| Night Vision | 100%                    | Detected     | 0%                   | Not detected |
| Edge         | 0%                      | Not detected | 0%                   | Not detected |
| Old          | 100%                    | Detected     | 100%                 | Detected     |

The results of marker detection tests show that the VUFORIA library is for Augmented Reality can detect features in markers even though they have been done manipulation, but the detection ability will not function when marker manipulation is too excessive, so VUFORIA can't do detection because of the feature illegible on the marker, due to the marker it's already too different from the actual marker.
Besides that, the VUFORIA library is still very dependent on the presence of light and the ability of the device camera. In the detection of marker with bright light (from sunlight), from 13 markers from the initial marker manipulation, there were 11 markers that were successfully detected 10 times with 100% on the percentage of marker detection and there are only two undetectable markers namely Edge and X-ray markers which are not detected with a value of 0% at the percentage of detection marker, and when testing marker detection with low light conditions (LED light) of 13 markers, there are 6 markers detected, namely Black & White, Comic, Vignette, Glow, Old Poster, and Old which have a value of 100% detection success percentage marker. And there are 7 undetectable markers, namely X-ray, Pastel, Pixel Blur, Inverse, Old Pastel, Night Vision, and Edge which get a value of 0% of the percentage of success of marker detection. So that it can be concluded that the decrease in light level will result in a dramatic failure of marker detection.

In addition to light, the VUFORIA library is also still very dependent on the detection distance, in the near range (0-15 cm) marker detection experiment in a light-deficient room (only using LED light), of the 13 markers tested, only 8 markers were perfectly detected, namely Black & White, Comic, Vignette, Glow, Old Poster, and Old, which get 100% percentage of marker detection success, while Blur Pixel marker gets 40% success rate Old Pastel marker and marker detection received 20% percentage of success in marker detection, in addition to these markers there were 5 markers that were not detected, namely Edge, Night Vision, Inverse, Pastel, and X-ray which got 0% of the success percentage. While at a distance (15-30 cm), of the 13 markers tested, there were only 5 perfectly detected markers, namely Comic, Vignette, Glow, and Old Poster which received a 100% percentage marker success, and Black & White markers get a 70% percentage of the success of marker detection, as well as Blur Pixel markers that get a 50% percentage value from the success of marker detection, but there are 6 undetected markers namely X-ray, Pastel, Inverse, Old Pastel, Night Vision, and Edge that gets a 0% percentage of success. This proves that VUFORIA is also still very dependent on the detection distance.

**Table 2. Short Range Detection Results (0-15 cm)**

| Image Mode   | Percentage | Test Results |
|--------------|------------|--------------|
| X-ray        | 0%         | Not detected |
| Black & White| 100%       | Detected     |
| Pastel       | 0%         | Not detected |
| Blur Pixel   | 40%        | Detected     |
| Comic        | 100%       | Detected     |
| Vignette     | 100%       | Detected     |
| Glow         | 100%       | Detected     |
| Old Poster   | 100%       | Detected     |
| Inverse      | 0%         | Not detected |
| Old Pastel   | 20%        | Detected     |
| Night Vision | 0%         | Not detected |
| Edge         | 0%         | Not detected |
| Old          | 100%       | Detected     |

**Table 3. Detection Results with the Distance of 15-30 cm**

| Image Mode   | Percentage | Test Results |
|--------------|------------|--------------|
| X-ray        | 0%         | Not detected |
| Black & White| 100%       | Detected     |
| Pastel       | 0%         | Not detected |
| Blur Pixel   | 40%        | Detected     |
| Comic        | 100%       | Detected     |
| Vignette     | 100%       | Detected     |
| Glow         | 100%       | Detected     |
| Old Poster   | 100%       | Detected     |
| Inverse      | 0%         | Not detected |
| Old Pastel   | 20%        | Detected     |
| Night Vision | 0%         | Not detected |
| Edge         | 0%         | Not detected |
| Old          | 100%       | Detected     |
3.2. The usability test

The usability testing was performed using questionnaires involving 30 secondary school students' examiners, and testers had never used this application. The questionnaire was containing 10 questions, which are classified based on the application functionality, user experience testing and testing based on the benefits of the application. As in Table 4.

| No | Interrogatory                                                                                     | Point |
|----|---------------------------------------------------------------------------------------------------|-------|
| 1  | Does the application feel fast when played?                                                      | 1 2 3 4 5 |
| 2  | Is the optimization in the application good?                                                     |       |
| 3  | Are all the buttons and features that are in accordance with their functions?                   |       |
| 4  | Are there applications running smoothly without any bugs?                                       |       |
| 5  | Does Augmented Reality in the application make you interested in buying items in the game?      |       |
| 6  | Does the application look attractive?                                                            |       |
| 7  | Are the markers used interesting?                                                               |       |
| 8  | Is this application easy to use?                                                                |       |
| 9  | Does this application provide benefits for you?                                                  |       |
| 10 | Do you want to use this application and buy a marker to buy weapons & items in the game?        |       |

The results of testing using the questionnaire on the table 5, we measure the performance the application in user perspective by using the formula:

\[ Y = \frac{P}{Q} \times 100 \]  

\( Y \) = The performance (Percentage Value).  
\( P \) = Total Score for each question.  
\( Q \) = Highest Point Number x Number of the Correspondents.

The results of this test are shown in Table 5, which shows the percentage results of each question asked.

| Category     | Application functionality | User experience | User Benefits |
|--------------|---------------------------|-----------------|---------------|
| Question     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Category     | 35%| 64% | 82% | 78% | 96% | 76% | 51% | 85% | 77% | 74% |

4. Conclusion and Further Research

From the results of testing markers, Vignette markers, Comic, Glow, Old Poster, and Old which were able to get a 100% value of detection success in several experimental conditions. There are also Blur Pixel markers which decrease the percentage of success to 0% when in low light, 40% at close range
and 70% at long distances, and markers that are manipulated become very different from the initial marker not detected by the application. So it was concluded that Augmented Reality is very dependent on light and distance in marker detection.

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