Implementation of Augmented Reality at Interactive Food Menu Using the Speed Up Robust Features (SURF) Algorithm

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Abstrak— Promotion is an attempt to notify or offer a product or service with the aim of attracting potential customers to buy or consume it, with the promotion, producers or distributors expect an increase in sales figures. In this study researchers used Augmented Reality technology for interactive media promotion of food menus by adding 3D multimedia elements. The method used in this study uses the Natural Feature Tracking method with the Speed Up Robust Features (SURF) algorithm, which detects local features in marker images that are resistant to rotation, scale and blurring. The results showed that the keypoint functions to render 3D objects. Search for keypoints is interrupted due to distance, light intensity and slope of the marker. Test results to see the distance between the camera and the marker as far as 60 cm. Medium light intensity that can detect markers, the average time of object speed can be displayed is 3.026 seconds and the marker slope limit is 30 °. This is because the keypoint readings at the position and time limit from keypoint readings clearly, keypoint readings clearly produce 3D objects can be displayed. This research uses the Android platform as the foundation of this Augmented Reality technology application. So that by displaying 3D food menu items in restaurants it is expected to be a means of promotion to attract consumers.
Keywords— Augmented Reality, Natural Features Tracking, Speed Up Robust.

I. INTRUDUCTION

The development of the business world is currently growing rapidly from various regions, this indirectly creates competition for business actors both in terms of quality and quantity of goods sold, including in the field of culinary business. One area with a high level of competition in the culinary field is Langsa City. In addition to one of the tourism areas that has interesting places to visit, Langsa City is inseparable from the various kinds of culinary that are sold, this is evidenced by the large number of restaurants scattered around the city of Langsa. The large number of new food potentials in Langsa City requires good and adequate publications and promotions so that information is widespread and can be recognized by the public.

Promotions can be done by anyone, including companies and business people, supported by technological advancements that are increasingly fast becoming, gadgets can now be used for promotional purposes. One of them is a restaurant that serves a variety of food menus that are supported by good promotions through social media, word of mouth information to distribute brochures. This can make it easier for consumers to choose the reference of food to be purchased. But if there are new consumers who do not know the restaurant and do not know the type of food sold, it will make it difficult for consumers to determine what foods to buy. The right solution for these problems is to apply Augmented Reality (AR) technology as a promotional media that will display certain information for its users. The use of Augmented Reality technology in restaurants or restaurants, especially the food menu list, then 3D objects about food contained in restaurants will appear virtually using an Android-based smartphone so that it will be easier to attract consumers to find out the food provided in the restaurant. Therefore it was made an application to introduce as well as promotional material about food sold from a restaurant / place to eat in the form of 3D objects using Augmented Reality technology and applying the SURF algorithm. The use of this application can be done with an Android smartphone camera. Consumers can see information in the form of visualization of food and know the details of the food to be purchased.

II. METHOD

A. Augmented Reality

According to Azuma in 1997, Augmented Reality (AR) is a technique to combine the real world with other worlds, and allow an object in cyberspace to be displayed with other objects in the real world simultaneously. Augmented Reality as a combination of real and virtual objects in a real environment, which runs interactively in real time. Augmented Reality is an additional reality that can complement different realities with Virtual Reality that really replaces reality. The development of Augmented Reality has reached various aspects of life, with Augmented Reality can make an object die as if it was turned on with the help of a camera that can be accessed on a computer or smartphone. With a marker we can see two-dimensional or threedimensional objects in a screen as a camera's focus point of reference [1].

B. Food

Food is needed for life because food is one of the basic needs of human life. Food serves to maintain body processes in growth or development and replace damaged body tissue, obtain energy for daily activities, regulate metabolism and various balances of water, minerals, and other body fluids, also play a role in the body's defense mechanisms against various disease [2].

C. Speed Up Robust Features (SURF) Algorithm

The SURF algorithm was first published by researchers from ETH Zurich, Herbert Bay in 2006. In its development

Herbert Bay was also assisted by two colleagues, Tinne Tuytelaars from Katholieke Universiteit Leuven and Luc Van Gool. SURF is able to detect local features of an image reliably and quickly. This algorithm is inspired by the Scale Invariant Feature Transform (SIFT) which first appeared in 1999, especially in the scale space representation stage. SURF algorithm uses a combination of integral image and blob detection algorithms based on determinants of the Hessian matrix [3].

SURF relies on image integrals, box filters, and Hessian matrices to speed up calculations. To find features, the Hessian matrix determinant is used. SURF uses 3x3x3 neighbors and the same feature elimination method with the SIFT method. Haar wavelet size 4 is applied to a radius around the keypoint. The results are weighted Gaussian and represented in the vector space. The dominant orientation is chosen by rotating the circle segment p / 3J K, and the highest vector is the vector whose orientation is used by the keypoint. Haar wavelets are also used to calculate gradients. Each region is divided into 4x4 sub-regions and each sub-region is divided into 5x5 sample regions so as to produce 64dimensional vectors [4].

a. Interest Point Detector

Interest point detector is used to select points that contain a lot of information and at the same time are stable against local or global interference in digital images. In the SURF algorithm, an interest point detector is chosen which has an invariant nature of scale, namely blob detection. Blob is broad in digital imagery that has a constant nature or varies within a certain range. To compute blob detection, we use the Hessian matrix determinant from the image. Previously the image was changed to grayscale first [4].

$$\frac{R+G+B}{3} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Information:
R :Red element
G : Green element
B : Blue element

b. Scale Space Representation

With different image sizes, it will be very difficult to compare the features found in the image. Therefore, a process is needed that handles size differences using a scale comparison method. In this method scale space is used where images are implemented in a pyramid image. The image repeatedly undergoes a smoothing process with Gaussian functions in succession by sub-sampling to reach the highest level in the pyramid [6].

$$\text{Pixel B}(i,j) = \frac{i}{k}\sum_{p=0}^{N-1}\left(\sum_{q=0}^{M-1} G(p,q).\ \text{pixel A}\ (i + p)\frac{(N-1)}{2}, j + q\ \frac{(M-1)}{2})\right) \ldots\ldots\ldots\ldots (2)$$

Information:
Pixel A = Picture A (Original Image)
Pixel B (i,j) = Multiplication weight at position (i, j)
N = Number of kernel matrix columns
M = Number of kernel matrix rows
K = Summing all the weights in G
G (p,q) = The kernel gauss matrix element at position (p, q)

$$G(i,j) = c.e - \frac{(i-u)^2 + j - v^2}{2\sigma^2} \ldots\ldots\ldots\ldots (3)$$

Information:
c dan σ = constants
G (i,j)= kernel gauss matrix element in position (i, j)
(u,v) = middle index of the gauss kernel matrix

Table 1: 3x3 Gauss Kernel Matrix

1	2	1
2	3	2
1	2	1

To find the keypoint the formula is used

$$\nabla f\sqrt{\Delta x^2 + \Delta y^2} \ldots\ldots\ldots\ldots (4)$$

Information:
Δx^2= Summing results between upper and lower pixel values (x)
Δy^2 = The sum result between the values of pixel (y) left and right

c. Feature Description

Feature is defined as a part that contains a lot of information about an image and is used as a starting point for object detection algorithms. The purpose of the feature description is to get a description of the features in the observed image. The first step is to see the dominant orientation of the attention points contained in the image, then build an area to be taken value and look for correspondence features in the comparison image. In determining the orientation of an image haar wavelet filters are used, here can be determined the slope level of an observed feature. Furthermore, for the feature description in SURF, only the gradient histogram calculation in four groups is used to speed up the calculation [5].

III. RESEARCH METODOLOGY

The general architecture of Augmented Reality can be seen in Figure 1

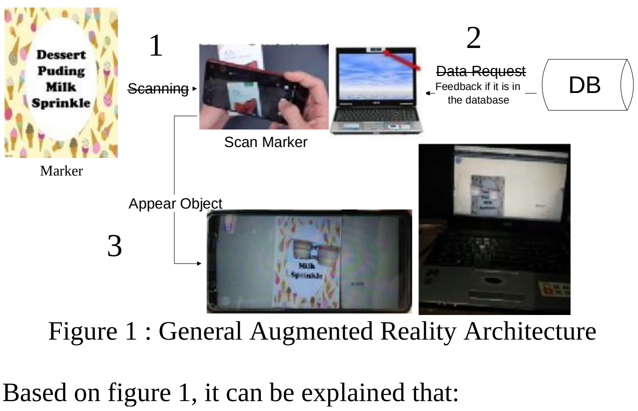

Figure 1 : General Augmented Reality Architecture

Based on figure 1, it can be explained that:

1. In this study to run the application requires a marker or marker that serves to display 3D objects in the real world. The marker used is paper with a variety of designs, both color, writing type and marker size. In order for these markers to function or be able to display 3D objects (virtual world), a tool is needed, in this study using a camera with an Android operating system and a laptop that

has previously been installed this Augmented Reality application. The camera performs a tracking process for the marker that has been prepared. In this process tracking of objects is done.
2. After the marker tracking process, the next process is requesting data or matching markers with images stored in the database, if the scanned marker matches the markers that are in the database, the application makes feedback on the data requests.
3. If the marker with images stored on the database from the target image matches, the 3D object is displayed according to the marker used.

The following is an overview of the object tracking process

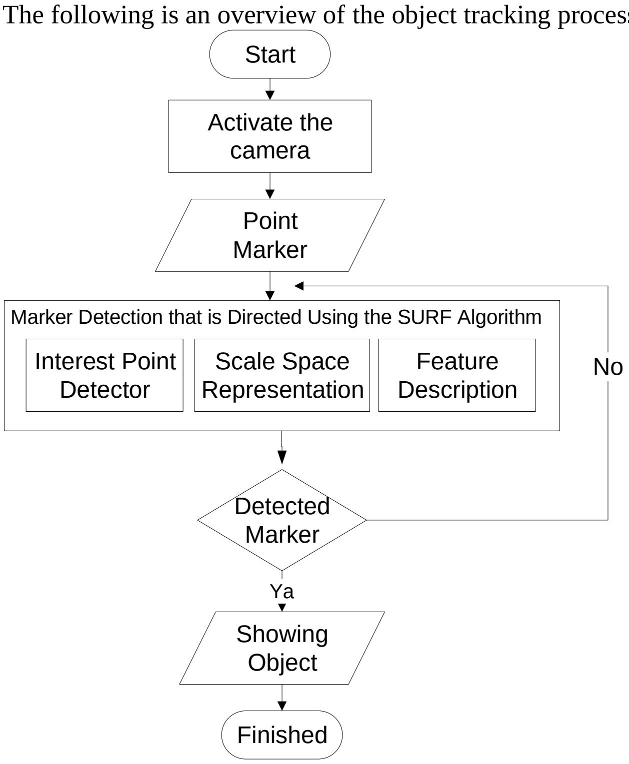

Figure 2: Augmented Reality Program Flowchart

Based on Figure 2, the Augmented Reality program flowchart can explain the steps of program processing starting from directing the marker to displaying 3D objects from the marker being detected

1. Start
   Starting the Augmented Reality program can be by opening a file with .apk extraction that has been created or installed on an android device
2. Activating the Camera
   After the program starts, it can activate the camera to track the marker
3. Directing Markers
   Direct the camera to the marker that was made before
4. Detection using the SURF algorithm
   a. Interest Point Detector
      Interest Point Detector is to choose a point that contains a lot of information and at the same time stable against local or global interference in digital images
   b. Scale Space Representation
      Compare pixel features by smoothing the marker image
   c. Feature Description
      Get a description of pixel features in the observed image.
5. Marker Detected
   After tracking process using SURF algorithm, the next step is whether the tracked marker is detected or not, if it is detected, then proceed in the next step, if not then the detection is done again.
6. Displaying 3D Objects
   The object appears after the marker can be detected

IV. RESULTS AND DISCUSSION

A. Distance Based Testing

Distance testing is done by bringing the marker closer to the camera, the size of the object to be displayed depends on the distance between the camera and the marker. The closer the camera is to the marker, the 3D food object that appears will be even greater, and vice versa. In this study the distance tested was from 20 cm to 100 cm.

Table 1: Marker Distance Testing

Number	Distance (cm)	Time (ms)	Test Display	Information
1.	20 cm	00.44 ms		Detected
2.	40 cm	01.4 ms		Detected
3.	60 cm	03.55 ms		Detected
4.	80 cm	04.30 ms		Not Detected
5.	100 cm	04.59 ms		Not Detected

Based on table 1 object can be displayed at a distance of 20, 40, and 60 cm, while at a distance of 80 cm and 100 cm objects cannot be displayed, this is due to the quality of the camera that cannot capture keypoints or patterns in the marker image that has been defined in the application. Each distance tested has a different time span when 3D objects appear, this is because the farther the marker object on the camera, the more difficult the camera to capture patterns that characterize the marker image.

So the level of accuracy of the success of distance testing in the marker image is Accuracy of $\frac{3}{5}$ x 100% = 60%

The level of accuracy of the success of distance testing is 60%, the test was unsuccessful on two data, namely at a distance of 80 cm and 100 cm.

B. Testing Based on Light Intensity

Light trials are carried out because the object rendering process can be interrupted by one of the factors, which is caused by light, the intensity of light that is too bright or too dark can affect the process of capturing marker images that cause 3D objects cannot be rendered.

Table 2: Testing of Light Intensity

Number	Light(lux)	Information	Test Display	Status
1.	2140 lux	Too Bright		Not Detected
2.	750 lux	Bright		Detected
3.	22.8 lux	Is Being		Detected
4.	0.54 lux	Dark		Detected
5.	0.15 lux	Too Dark		Not Detected

Based on table 2, the results of the program output have been successful in displaying 3D food objects at light to dark intensity. The trial did not succeed at the intensity of the light too dark and too bright, this is because the interactive application food menu camera cannot recognize objects that are inputted or do not get keypoints from marker images that have been initialized in the application. The accuracy of the program's success in testing the intensity of light is Accuracy of $= \frac{3}{5}$ x 100% = 60 %.

So the level of accuracy of the program's success in testing the intensity of the marker image is 60%.

C. Testing Marker Slope Limit

Testing the marker slope is done to determine the exact tilt level of the marker in the tracking process and find out the position of the slope boundary that cannot be detected. Testing is done with a distance of 40 cm from the device's camera which has an interactive food menu application installed.

Table 3: Slope Boundary Testing

Slope Limit				
0°	15°	30°	45°	60°
				
Detected	Detected	Detected	Not Detected	Not Detected

Based on table 3 the slope boundary test results in markers with a slope of 0 °, 15 ° and 30 ° were successfully carried out. 3D objects that have been determined on the marker are successfully displayed, but at the 45 ° and 60 ° degrees 3D objects cannot be displayed, this is because the reading of the points that become the keypoint is not clear when the image is inputted through the camera.

The accuracy of the success of the trial slope boundary for the marker isAccuracy of $= \frac{3}{5}$ x 100% = 60%

So, the success rate of the trial slope limit for markers is 60%. Where in the calculation above there are 3 numbers taken from the number of successes of the markers tested while the value of number 5 comes from the number of experiments conducted so that the calculation results obtained by 60% success.

D. Time-based Testing of Tracking

The tracking time test is carried out on 3 (three) devices, namely the Acer laptop with 2 GB RAM size, Android 2 GB Samsung Ram and android Vivo 4 GB.

Table 4: Time Tracking Results

Nama Marker Makanan	Waktu Pemindaian oleh kamera perangkat (detik)			
	Laptop Acer RAM 2 GB	Laptop Lenovo corei3 RAM 3 GB	Vivo V7 RAM 4 GB	Samsung Grand Prime 1 GB
Donat	01.06	01.41	00.71	01.01
Jadeh Lemang	01.05	01.09	00.61	01.01
Mochie	01.06	01.85	01.04	01.00
Tahu Bayam	01.05	01.12	00.86	00.08
Cheesecake	01.01	01.05	00.65	00.08
Kopi Ule Kareng	01.02	00.19	00.41	01.00
Sosis Bakar	01.06	01.26	01.06	00.09
Puding Milk Sprinkle	02.01	01.19	00.65	01.02
Jumlah	**09.32**	**09.16**	**05.99**	**05.29**
Rata-rata	**1.165**	**1.145**	**0.748**	**0.661**

Based on table 4.15 the results of tracking time are obtained on different devices. As seen in the tab, devices with the same type don't have much time difference. On Acer laptops the 2GB RAM with the fastest Lenovo core i3 3GB RAM laptop is the Lenovo laptop, but on the Android Vivo v7 4GB RAM device with the Samsung Grand Prime which only has 1GB of RAM, the speed is superior, from Samsung smartphones. In the trial conducted RAM on the device does not affect tracking speed, but in terms of speed when opening the Interactive Menu Food application is very influential.

Devices that have low RAM capacity take longer than devices with greater RAM capacity in running applications.

V. CONCLUSION

1. Marker detection through a device camera that has been installed an interactive food menu application uses the SURF algorithm capable of capturing every marker that wants to be tracked. In addition, the SURF algorithm search results can be done using pixel features that are resistant to rotation, scale / size and bluring / lighting. The test results have succeeded in proving the reliability of SURF, this is seen from the detection of objects working stably at a fairly bright light intensity, the closer the marker distance to the camera, the object will be detected faster and able to detect objects whose angles reach 30 °

2. In displaying 3D marker objects the closer the distance between the marker and the camera, the greater the object displayed, on the contrary if the distance between the camera and the marker is getting farther the distance displayed is also getting smaller, even the object cannot be displayed because the keypoint is not detected. In this study the maximum distance of the detected marker was 60 cm
3. From the test results obtained different levels of accuracy, testing the slope limit of 60%, testing based on a distance of 60%, testing based on light intensity 60%, Accuracy of success in each test with an accuracy of less than 100% due to the keypoint in the marker cannot be read clearly by the interactive food menu camera, it causes objects to not be displayed and the level of accuracy decreases on each test.

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