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Implementation of Augmented Reality of Laboratory Building and Room Using Fast Corner Detection Algorithm

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ABSTRACT
The Laboratory Buildsing is one of the buildings in Campus IV UINSU which is used to carry out practicum activities, many of the lecturers students and the community do not know the location and also the rooms in the Laboratory building. This research aims to make this application can provide convenience for users such as students, lecturers and the public to obtain information about laboratory buildings. In this research, the method used is Marker Based Tracking where application users must scan the marker first in order to see 3D objects from a floor plan and laboratory building. The results of this study in the form of Augmented Reality applications using Android as an operating system, on the marker added with the Fast Corner Detection algorithm aims to speed up real-time computing time with the consequence of reducing the level of accuracy of corner detection. The conclusion of AR and Fast Corner Detection can be implemented through a scan of the marker, the result obtained is that when scanning the marker a point from the FCD algorithm will appear indicating that the point on this marker is the result of the implementation of the FCD algorithm.

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1. INTRODUCTION

The term Augmented reality refers to passive or interactive interaction with a physical world that has been altered by integrating virtual computers that generate information [1]. Augmented reality aims to develop technologies that allow real-time merging of digital content created by computers with the real world. Augmented reality allows users to see two-dimensional or three-dimensional virtual objects projected onto the real world [2]. This AR technology can insert certain information into the virtual world and display it in the real world with the help of equipment such as webcams, computers, Android phones, and special glasses. Users or users in the real world cannot see virtual objects with the naked eye, to identify objects an intermediary is needed in the form of a computer and camera which will insert virtual objects into the real world [3].

Marker Based Tracking is [4] AR that uses markers or markers of two-dimensional objects that have a pattern that will be read by a computer through a webcam or camera connected to a computer, usually a black and white square illustration with thick black borders and a white background [5].

The Features from Accelerated Segment Test (FAST) Corner Detection (FCD) algorithm is a corner point determination or corner detection to detect the corners of an object developed in 2006 by Edward Rosten and Tom Drummond. This algorithm uses the principle of square analysis to quickly detect each corner of the image. The purpose of Fast Corner Detection is designed to track computer time in real time while minimizing the threshold for successful corner detection [6].

One of the buildings on the UINSU IV Tuntungan campus is the laboratory building. UINSU IV Tuntungan laboratory building is a place for practical or research activities supported by the availability of a set of practical tools and complete infrastructure in the laboratory. During practicum activities and events held by the campus, some of the students, lecturers and the community, especially not permanent UINSU lecturers and the community, have difficulty finding laboratory buildings and rooms, because the location of the laboratory building is at the end of the campus entrance, so students, lecturers and the community cannot know the location of buildings and rooms clearly, therefore an information media is needed that makes it easy to find the location of buildings and laboratory rooms on the UINSU IV Tuntungan campus, one of which is Augmented Reality.

This research was developed based on previous research ideas previously conducted by Hafshah Nuridz Dzakiyyah in 2019, The research discusses building 3D Augmented Reality objects as an introduction to historical iconic buildings using the Marker Based Tracking method and using the FCD Algorithm. In its design, the application was made for the recognition of iconic historical buildings in the world and tested markers with the FCD algorithm, while the researcher designed an Augmented Reality application using Marker Based Tracking which creates building objects and laboratory rooms and then tests the markers with the FCD algorithm by manual calculation [7].

From these problems, the author made an Augmented Reality (AR) design to overcome the problem of difficulty finding the layout of the building and laboratory space which is located at the end of the building so that it is difficult to find the location of the building. This research aims to make this application easier for users such as students, lecturers, and the public to obtain information about laboratory buildings. The difference between this study and the previous research is that this research focuses on promoting campus facilities while the previous research aims to introduce historical buildings. It is hoped that users can use this application well to recognize the layout of the laboratory building and its room plan.

2. LITERATURE REVIEW

2.1. Augmented Reality

Augmented Reality is the interaction between real objects and virtual objects in a real environment that occurs interactively with a certain period of time. There is integration between objects in three dimensions, namely virtual objects that are integrated with the real world [6]. Unification is made by technology with appropriate displays, interactivity is made possible by various input angles, and proper integration requires effective tracking [8]. Marker-based tracking and markerless are two types of Augmented Reality methods [9].

2.1. Marker Based Tracking

Marker Based Tracking is a method that has long existed and developed in the 1980s, and in the 1990s began to develop for Augmented Reality users [10]. Marker based tracking is an augmented reality technique that marks markers and identifies marker patterns to insert virtual objects in a real environment[11].

The marker has a black and white square image with thick black sides, a black pattern in the middle of the square and a white background [12]. The computer will know the location and orientation of the marker and produce a 3D virtual world, namely the point (0,0,0) and 3 axes, namely X, Y, and Z [13].

2.2. Fast Corner Detection

Features from Accelerated Segment Test (FAST) Corner Detection or the FCD algorithm is known as corner point detection. This FCD algorithm is designed to increase the speed of real-time calculation time by decreasing the accuracy level of corner detection. FCD begins with determining pixel p at coordinates (Xp, Yp) surrounded by 16 pixels. Next, comparing 4 pixel coordinates with a radius of 3 pixels each in finding the corner point. At least three points of intensity value at point p have met the value that is greater or smaller than plus the threshold intensity, then point p can be declared as the sought-after corner point [14].

The FCD has a working corner detection algorithm, as follows:

1. Determine a point p in the image with an initial position of (Xp, Yp).
2. Determine 4 points. The first point (n = 1) is at coordinates (Xp, Yp+3), the second point (n = 2) is at coordinates (Xp+3, Yp), the third point is at coordinates (n = 3) is at coordinates (Xp, Yp-3), the fourth point (n = 3) is at coordinates (Xp-3, Yp).
3. Compare the intensity of the four points around the center point p. A corner point is the center point of p if at least three points meet the following criteria
   Sp - x =
   Ip - x ≤ Ip - t (Darker)
   Ip - t < Ip - x < Ip + t (Similar)

$Ip + t \leq Ip - x$ (Brighter)
Description:
Ip = pixel intensity
t = treshold

4. Repeat the procedure until all image points have been compared with their intensity [15].

3. RESEARCH METHOD

The research method used in this study is a qualitative method. This research method was chosen because it was considered appropriate because this research focused more on the process of developing AR applications and how this technology can be implemented, rather than generating quantitative data. The flow of research methods in this study uses the following research framework, as figure 1.

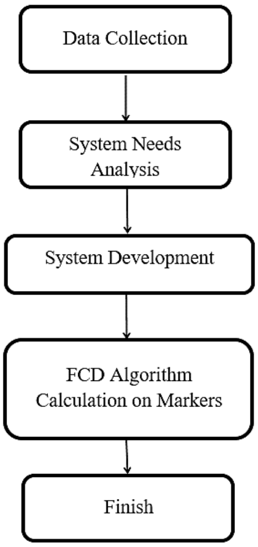


Figure 1. Research Flow

The steps in qualitative research:

1. Data collection, the data collection method carried out in this study is carried out in three ways, namely observation, interviews and literature studies.
2. System Needs Analysis, the system needs needed in building applications in this study which aim to design and manufacture the system, namely hardware and software.
3. System Development, the system development method used in this study is Rapid Application Development (RAD).
4. Fast Corner Detection Algorithm, this study uses a fast corner detection algorithm using a two-dimensional marker or object marker that has a pattern that will be read by a computer through a webcam or camera connected to a computer for the reading of the marker point.

3.1. System Development Method

Rapid Application Development (RAD) will be used as the system expansion method. Rapid Aplication Development is a model for linear sequential software upgrades used for a series of very minimal upgrades [16]. RAD can be used as a guideline for improving an information system that is sensitive to changes in speed, accuracy, and cost that can be determined more accurately guide [17].

The reason for increasing user satisfaction, the Rapid Application Development (RAD) approach was chosen because it has several advantages, such as a more flexible and agile development process, and the ability to minimize failure [18].

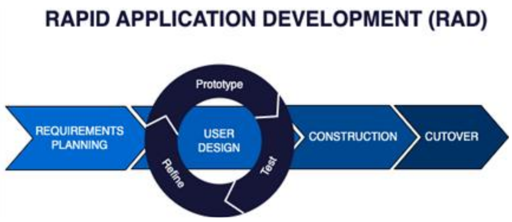


Figure 2. Stages of RAD Method

1. Requirements Planning, at this stage users and writers work together to investigate and solve problems that arise, because this is the first step in the successful creation of the system and can prevent communication errors between users and writers, it must be determined what is needed to create an application system.
2. User Design, the stage of creating a plan that will be used to meet the needs, follow the plan, and is expected to solve the problem. This study describes the system design using the Unified Modeling Language (UML) tool.
3. Construction, this is the first step to creating the designed system. To modify the system into a usable application, start writing program code.
4. Cutover, at this stage, the system as a whole is tested using Black Box testing, a software testing technique that focuses on its functional specifications [18] .

3.1. Marker Based Tracking Method with Fast Corner Detection Algorithm

Marker-based tracking is AR that uses markers and can be read on two-dimensional objects by a computer through a webcam or camera connected to a computer. This black-and-white image has a thick black border and a white background [19].

FCD has a way of working and an example algorithm case, as follows:

1. Determine a point p in the image with an initial position of (xp,yp). Determine a point p in the image with initial position (x,y) and threshold value.

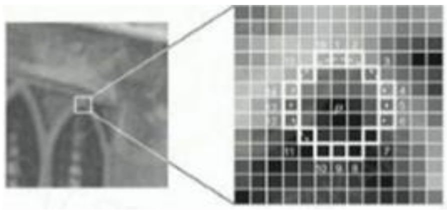


Figure 3. Starting point

2. Identify the four points. The first point (n=1) is at coordinate (xp,yp+3), the second point (n=2) is at coordinate (xp+3,yp), the third point (n=3) is at coordinate (xp,yp-3), and the fourth point (n=4) is at coordinate (xp-3,yp).

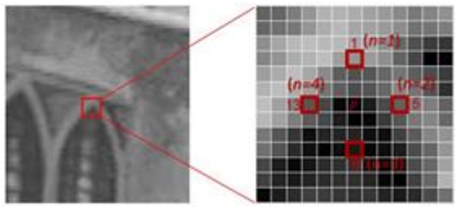


Figure 4. The four coordinates

3. Compares the intensities of the four surrounding points with the center point p. The center point p is an angle point if three points at least satisfy the following conditions.

$$Sp\to \mathrm{x} \begin{cases} d, & Ip \to x \leq Ip - t \quad (darker) \\ s, & Ip - t < Ipx \leq Ip + t \quad (similiar) \\ b, & Ip + t \leq Ip \to \mathrm{x} \quad (brighter) \end{cases} \tag{1}$$

Description:
Ip : Pixel intensity
t : threshold

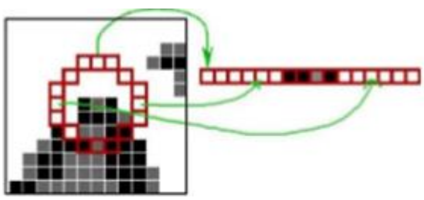


Figure 5. Three points met

4. Repeat the procedure until all image points have been compared with their intensities [20].

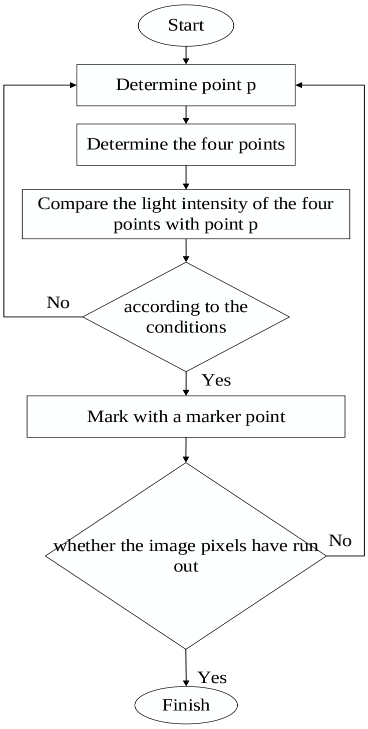


Figure 6. How FAST Corner Detection Works

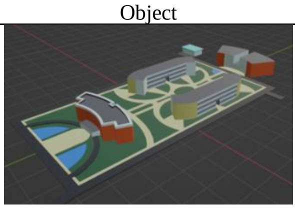
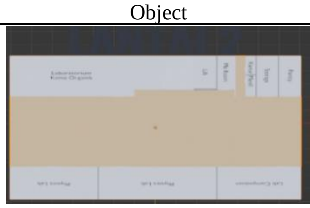
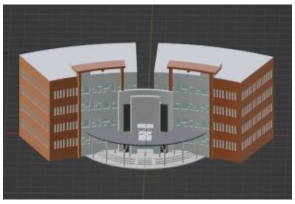
4. RESULTS AND ANALYSIS

4.1. Requirements Planning

In order for the system process to run effectively and efficiently, requirement planning is needed. The following requirement planning is determined by the researcher.

1. Application of 3D Objects
   There are several objects used to build an application, among others.

Table 1. 3D Objects

No	Object	Description	No	Object	Description
1		UINSU floor plan	4		2nd floor
2		Laboratory Building	5		3rd floor
3		1st floor	6		4th floor

2. Marker Application
   In the application of markers, the author uses marker-based tracking where a marker is needed in order to bring up the desired object. The markers used in the application to bring up 3D objects include.

Table 2. Marker

No	Marker	Description	No	Marker	Description
1		Campus floor plan marker	2		Laboratory Building Marker

4.2. User Design

The next step is to determine how the process of making an augmented reality application design for the building and laboratory room of UINSU campus IV. The following is a Flowchart on application design.

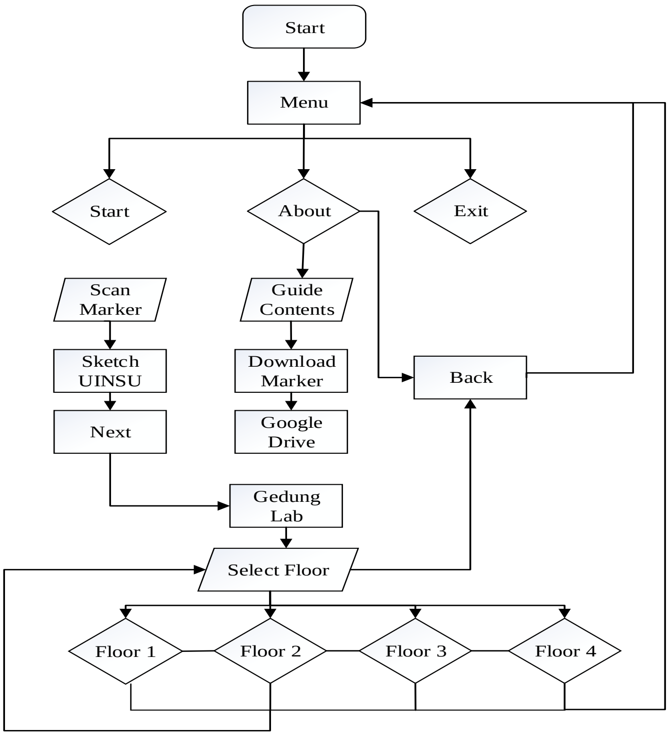


Figure 7. Application Flowchart

4.3. Construction

1. Use Case Diagram
   Use case diagram show the relationship between the user and the system in the application and the limits of the system that can be used by the user.

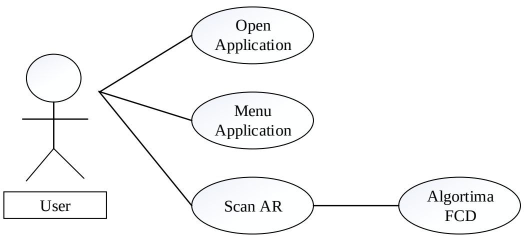


Figure 8. Use case diagram of the system

2. Activity Diagram
   The next step is the activity diagram which serves as the flow of activities that occur in the system. Use case diagrams used in this application contain user activities in the menus in the application.

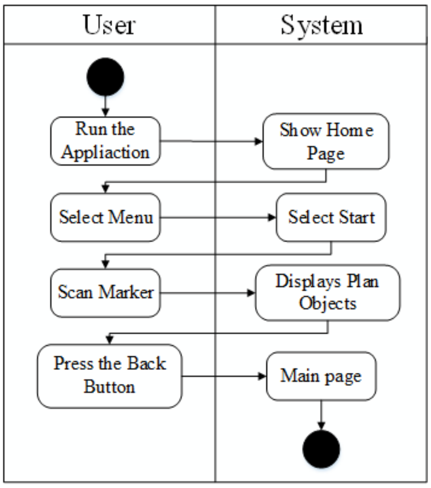


Figure 9. Start and Scan Menu Activity Uinsu Floor Plan Map

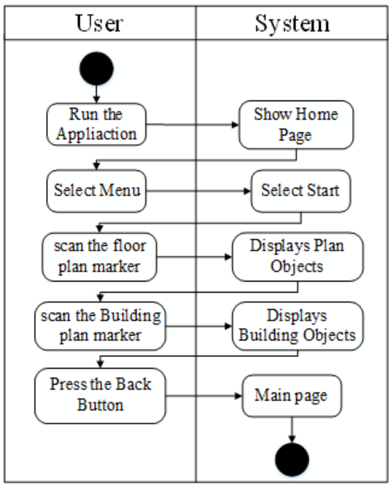


Figure 10. Scan Menu Activity Laboratory Building

4.4. Interface Result

This research produces products in the form of applications that can be used by users (students, lecturers, and the public). The interface is an application display that will be used by the user to run the augmented reality application of Campus IV UIN Sumatera Utara Laboratory Buildings and Rooms. The application is designed with an intuitive interface to make it easier for users to operate the application.

1. Application View
   Pada aplikasi ini terdapat 4 menu diantaranya : Mulai, Tentang , Unduh Marker dan Keluar. Aplikasi akan dimulai ketika sudah menekan tombol menu “Mulai” lalu scan marker maka objek akan keluar, terdapat 6 object diantaranya: denah kampus UINSU, Gedung Laboratorium dan Lantai Gedung 1-4.

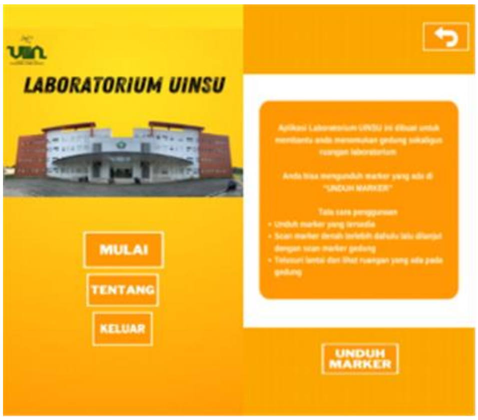


Figure 11. Main Menu and About

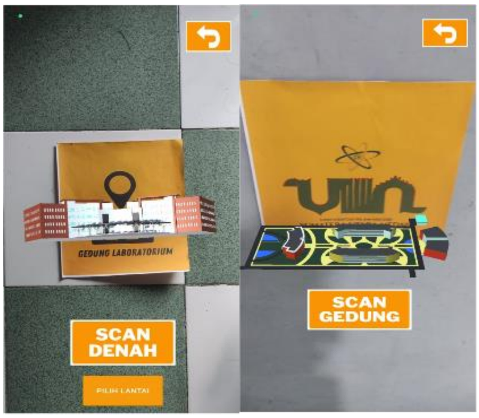


Figure 12. Marker Scan

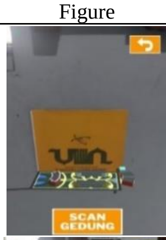
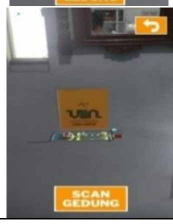
2. Testing Light Intensity and Distance on Marker
   This test tested the light intensity on the camera with a marker to find out how dark and bright it is to scan a marker, show as table 3.

Table 3. Testing Light Intensity

No	Situation	Image	Description	No	Situation	Image	Description
1	Daytime in an open area		Marker detected, 3D object displayed perfectly	3	Nighttime with lamp lighting		Marker detected, 3D object displayed perfectly
2	Daytime in an enclosed area		Marker detected, 3D object displayed perfectly	4	Nighttime in the dark		Marker not identified, 3D object not displayed

3. Distance Testing on Markers
   This test tested the distance between the camera and the marker to determine how far it can be scanned.

Table 4. Marker Angle Testing

No	Distance	Figure	Description	No	Distance	Figure	Description
1	20 cm		Marker detected, 3D object displayed perfectly	3	60 cm		Marker detected, 3D object displayed perfectly
2	30 cm		Marker detected, 3D object displayed perfectly	4	90 cm		Marker detected, 3D object displayed perfectly

4. Blackbox Testing

Table 5. Blackbox Testing Application

No	Button	Button Description	Expected Results	Results
1	Start	App Home Page	Display the menu	Valid
2	Start	Scan AR button for uinsu floor plan section	Displaying Scan AR and after scanning the marker object 3D map uinsu is displayed	Valid
3	Download Marker	Button to download the required marker	Go to web things go to google drive	Valid
4	About	Description of the augmented reality application of laboratory buildings and rooms on campus IV Uinsu	Displays a page containing	Valid
5	Next	Button to Scan AR for laboratory building section	Display Scan AR and after that scan the 3D object marker of the laboratory building	Valid
6	Select Flooring	Button to display building floor options	Display 3D Objects of building floors 1-4	Valid
7	Back	Button to return to the main menu section	Return to the main menu	Valid
8	Exit	Exit button from the app	Exit the app	Valid

5. Marker Based Tracking with Fast Corner Detection Algorithm
   The process of how markers in AR work with the FCD Algorithm can be seen in the figure below as follows.

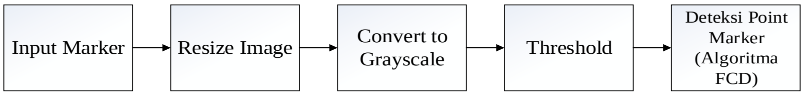


Figure 13. Stages of the marker tracking process

The following is the process of calculating the FCD Algorithm against the marker as follows.

1. Determine the point that will be the center point in the image, here the marker is the UINSU symbol, from the UINSU marker, the point that will be the center point is taken.

Figure 14. Determining the starting point P

2. From the center point that has been determined, the Ip value can be found, to find the Ip value is the R + G + B / 3 value.
   RGB values are known as follows:
   R: 35
   G : 73
   B : 19
   $Ip = \frac{35+73+19}{3} = \frac{127}{3} = 42$

3. Define 16 pixel points

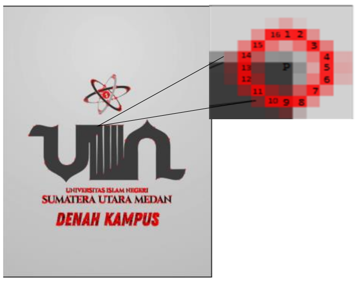


Figure 15. Specifying 16 point pixels

Figure 16. Pixel value slice in RGB image

4. Determine four points from 16 pixels. The initial point (n=1) is at (xpp, ypp+3), the second point (n=2) is at (xpp+3, ypp), the third point (n=3) is at (xpp, yp-3), and the fourth point (n=4) is at (xpp-3, yp). As in the figure 18.

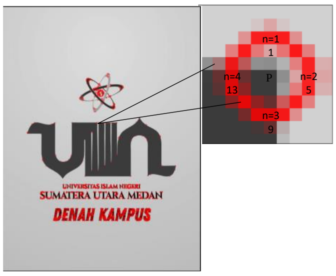


Figure 18. Points n=1, n=2, n=3, n=4

5. Compare points n=1, n=2, n=3, and n-=4 with the center point, if there are three points that meet the requirements, then the center point is the corner point. The following is the calculation of the FCD Algorithm against the marker:

   a. Point n=1
   R = 251, G = 204, B = 26
   $Ip = \frac{251+204+26}{3} = \frac{481}{3} = 160$
   Then Ip n=1 is 160
   Ip = 160
   t = 127
   Then compare with point p
   Result: 42 ≤ 160+127 → 42 ≤ 287 (brighter)

   b. Point n=2
   R = 251, G = 204, B = 26
   $Ip = \frac{251+204+26}{3} = \frac{481}{3} = 160$
   Then Ip n=2 is 160
   Ip = 160
   t = 127
   Then compare with point p
   Result: 42 ≤ 160+127 → 42 ≤ 287 (brighter)

   c. Point n=3
   R = 34, G = 72, B = 18
   $Ip = \frac{34+72+18}{3} = \frac{124}{3} = 41$
   Then Ip n= 3 is 42
   Ip = 41
   t = 127
   Then compare with point p
   Results: 42-127 < 41 < 42 + 127 → -85 < 41 < 169 (Normal)

   d. Point n=4
   R = 37, G = 74, G = 19
   $Ip = \frac{37+74+19}{3} = \frac{130}{3} = 43$
   Then Ip n= 4 is 42
   Ip = 43
   t = 127
   Then compare with point p
   Result: 42-127 < 43 < 42 + 127 → -85 < 43 < 169 (Normal)

6. Perform the process again until the intensities of all points in the image are compared.
7. If the conditions are met, the object will appear.

5. CONCLUSION

Based on the results of the discussion, the researcher concluded that this study successfully implemented Augmented Reality (AR) technology to provide visual information about the building and laboratory room at Campus IV of UINSU. By using the FAST (Features from Accelerated Segment Test) Corner Detection algorithm, this AR application is able to detect and track the corners of the room quickly and accurately, which is then used to display AR information in real-time. However, there are obstacles that are still experienced in the use of this application, such as the success of angle detection and tracking is highly dependent on the quality of the camera used. Low-resolution or poor-performing cameras can degrade the quality of the AR experience.

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