Development of Virtual Painting Method using OpenCV Library with Finger Gesture on Online Learning Platform

Glenn Ramadhan[1),]Jansen Wiratama[2),]Angga Aditya Permana[3)]

[1, 2] Information System, Faculty of Engineering and Informatics, Universitas Multimedia Nusantara, Tangerang, Indonesia
[3] Informatics, Faculty of Engineering and Informatics, Universitas Multimedia Nusantara, Tangerang, Indonesia
Co Responden Email: jansen.wiratama@umn.ac.id

Abstract

With the pandemic situation that has occurred for the last two years to date, educators and students carry out many learning activities online. Learning activities are carried out using virtual meeting media, the concept of meetings and discussion processes that are carried out virtually with existing digital communication devices. From the problems, it was found that students were likelier to be less active when learning theory than practice, which made it difficult for educators to find various media that would be given to students to support online learning activities to be more interactive. This study discusses the creation of a system that can be a medium for delivering helpful material to improve the quality of interaction between educators and students. A virtual painter is one of the media to support the online interactive learning process, where educators can complete the material presented with a clearer picture that educators provide to students. Virtual painters are used to tracking finger pattern movements where the user moves his hand as needed, namely drawing and release, which educators can use to deliver more interactive material to students in theoretical and practical learning. The system design method used in building the virtual painting is Rapid Application Development (RAD) which is carried out through 8 stages, starting from Requirements Analysis to Operation and Maintenance. Next, the diagram design uses UML notation and the phyton with OpenCV coding process. After the virtual painter had been made, an evaluation was conducted and resulted in a positive impression of all six scales: attractiveness, efficiency, clarity, precision, stimulation, and novelty.

INTRODUCTION

The process of learning and teaching activities between educators and students has many influencing factors in it, including the factors of educators, facilities or infrastructure, the learning environment, the curriculum used for learning, as well as from the input of the students themselves (Maharani et al., 2018).

However, during the pandemic, all learning activities are carried out online. With this situation, educators have a new challenge, which is to create a variation to make learning more interactive during distance learning (Hasibuan & Damanik, 2020).

From the problems that occur when the online learning method takes place, it is found that students are more likely to practice learning compared to theoretical learning, and this makes it difficult for educators to find media variations that educators will provide to students to be active when online learning

takes place (Maharani et al., 2018). The use of interaction media in the course of the learning process in the classroom serves to attract the attention of students who will make the motivation and activeness of students when the provision of material by educators becomes more improved, not only listening and reading materials prepared by educators, students can also see a clearer picture of the material provided by educators, with the direction of good educators will get support to improve results from educators. Learning (M, 2020).

Virtual meeting is a concept meeting or discussion process that is done virtually using existing digital communication devices. Virtual meetings are currently used as a means of interaction media to conduct distance learning activities online that were imposed when the pandemic began. To support interactive virtual meeting activities between educators and learners, educators need other supporting media to improve the quality of

interaction to students. Virtual painter is a supporting media application to help educators to add a variety of learning media that are more interactive delivery to students.

Virtual painter is used based on tracking hand movements where the user moves the hand according to needs, namely drawing and removing. By running this virtual painter, the user's camera will be activated and allow the user to draw in the air by waving his hands according to their needs.

Previous research has discussed the creation of virtual painters with the aim of the research to test the use of features of virtual painters, such as testing virtual painting using the Python programming language, creating drawing applications using webcams and using libraries from OpenCV and numpy, and discussion of the efficiency of virtual painters. for efficiency of use in the online learning process by using OpenCV. The difference from the virtual painter application in this study from previous research is to add a feature using finger pattern detection used to perform drawing and removing functions, where previous virtual painter applications had to use color object detection to be able to perform functions and in this study aims to make virtual painters as a choice of media variations to be a means of assistance in making the learning process more interactive (Saurabh et al., 2021).

For virtual meeting applications already have a sketch feature where this feature serves to draw and give a mark on the writing of material (Budijono & Tanutama, 2021). What distinguishes from the use of virtual painter with sketch feature in the virtual meeting application is for the use of virtual painter using the detection of movement patterns of finger segments on the hand used to carry out drawing and removing functions that serve to provide an overview of the material during the learning process.

In this research, virtual painter was chosen to be a media means to be a media support for teaching and learning activities that are more interactive, because the function of virtual painters who are drawing and removing can be used by educators to convey material that is an object image to students, and the function of cameras used as image capture

educators for students can pay attention to educators while explain the ongoing material.

To explain the background more easily understood, some terms related to the theory used in this study will be described as follows:

A. Virtual Meeting

Virtual meeting is one of the online meeting media whose media combines several elements such as text, sound, images, and video interactively that use technology such as computers and smartphones as their tools (Mazda & Fikria, 2021). The image taken from the camera and the process of limiting the input of a wide set in discrete form is called a digital image (Kaesmetan, Y., & Overbeek, M. 2022). Virtual meetings have also evolved now to help to carry out educational activities and do work remotely from home (Budijono & Tanutama, 2021).

B. Virtual Painter

Virtual painter is a medium that uses the OpenCV module and python programming language, providing real-time webcam data used as object detectors that allow users to draw simple shapes and delete by moving the position of the gesture pattern of the user's fingers (Srungavarapu et al., 2021).

C. Python

Python is a programming language created by Guido van Rossum in 1991. Python supports many programming paradigms that include object-oriented, imperative, functional and procedural and also has a large standard and complete library (Primož Podržaj & Boris Kuster, 2018). Python is defined as a programming language that combines capabilities with clear code syntax and enormous library functionality. Python is an open source that has no restrictions on distributing it, and also with automatic memory management, making Python a dynamic programming language (Pulungan et al., 2021).

D. Mediapipe

Mediapipe is a framework used to build pipelines to infer to arbitrary sensory data. Mediapipe is designed for students, researchers, practitioners, and software developers to build machine learning. The mediapipe use case is for rapid prototyping of pipeline perception with inference models and other reusable components (Lugaresi et al., 2019).

E. OpenCV

OpenCV (Open source Computer Vision) is a real-time image processing software library created by Intel and supported by Willow Garage and Itseez. OpenCV is released under a BSD permissive license that can give you the freedom to be used commercially without the need to list sources. OpenCV also supports other programming languages such as C++, C, Python and Java and also supports in some virtual painter operations such as Windows, Linux, Mac OS, iOS and Android (Zein, 2018). OpenCV is also designed for efficiency in building a machine learning architecture that can track and process data and manipulate it in real-time (Patil et al., 2020).

F. Hand Tracking Module

Hand tracking Module is one of the modules of the OpenCV library whose function is to detect the movement of the fingers in real-time and maximize detail. It can detect and recognize finger segments with the use of Python and OpenCV libraries in any state of light, pose, or hand shape orientation (Ismail et al., 2021).
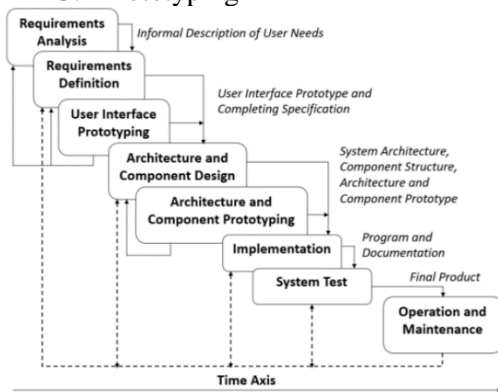
G. Prototyping

Figure 1. Prototyping Method

Prototyping is a technique for collecting information about user information needs quickly, which focuses on presenting the aspects of the virtual painter that will be used by the user (Pricillia & Zulfachmi, 2021).

H. Unified Model Language (UML)

UML (Unified Modelling Language) is one of the tools used to design software development or virtual painter based on object-oriented. Unified Modeling Language provides a standard writing virtual painter blueprint, which essentially covers business processes, classes, database schemes, and components needed in the design of virtual painter software or virtual painters (Dennis, Alan, Barbara Wixom, 2015). Unified Modeling Language modeling also provides

convenience and development in virtual painters and is able to know the flow of virtual painters expected from previously arranged planning (Dennis, Alan, Barbara Wixom, 2015).

1. Use Case Diagram

Use case diagrams are activities and interactions that are interrelated between actors and functions. Use Case Diagram to represent user interaction with the application (Suryadibrata, A., & Young, J. 2020). Serves as a technique that uses it for software development to know the virtual painter (Hafeez et al., 2019).

2. Class Diagram

Class diagrams are core depictions of diagram structures used in various activities in various activities in the development of virtual painters. Class diagrams are also structures because of their functions that describe what things should be in a virtual painter modeled with various component (Hafeez et al., 2019).

3. Activity Diagram

Activity diagram is a modeling flow of activities in the virtual painter that is in the process of being worked on, where each activity begins, the events that are likely to occur, and how the virtual painter ends. Activity diagram is also a development of a use case that already has activity in it, activity diagrams do not have actor behavior in them, but activity diagrams can be used as a depiction of virtual painter workflows (Hafeez et al., 2019).

4. Sequence Diagram

Sequence diagram is a diagram to equalize the interaction between actors and objects in virtual painters arranged sequentially (Wahyudi et al., 2019).

RESEARCH METHODOLOGIES

A. Research Object

The research objects studied and used in this research are educators who are implementation actors to implement teaching and learning activities that have the goal to meet the achievement of learning quality from learners, and students who are recipient actors who experience the process of development from guidance obtained from what is applied by educators. The research object focuses on the perpetrators of teaching and learning activities conducted by educators and learners virtually.

B. System Design

Based on the comparison of RAD and Prototyping development methods in the development stage, in this application it is determined to use prototyping methods in carrying out the construction of virtual painters which is because in changes in functions can be done individually without requiring team management in making changes to function at Virtual. Painter, then this research focuses on meeting what is the needs of the user at this time.

The stages that will be carried out in the process of using the prototyping method are:

1. Requirements Analysis.
   Carry out gathering information about the system users in virtual meeting facilities currently need so that the created system can help users make learning methods more interactive.

2. Requirements Definition.
   Perform restrictions on the system that will be made with recommendations from users. The application will be made with a finger gesture pattern detection system captured by the camera using the python programming language and the OpenCV library. In this study, the camera used is a webcam camera.

3. Design Prototyping.
   The design phase of the Graphical User Interface (GUI) for the initial display will be designed with a user-friendly concept so that it is expected to be easier to understand and more in line with user needs. This stage will start from drawing the sketch and will be checked against the user so that the Graphical User Interface (GUI) created can meet the needs.

4. Architecture and Component Design
   Making a system design based on the required architecture based on the flow made with Use Case Diagrams and Class Diagrams.

5. Architecture and Component Prototyping.
   Prototyping design components based on designs that have been made using Activity Diagrams.

6. Implementation.
   Making a Real-Time Painting system using the Python programming language, the application contains a hand tracking process that will detect hand gesture patterns and carry out existing functions according to the specified pattern.

7. System Test.

The test will be divided into 2, the researcher will carry out the first test, and the system user will carry out the second test.

8. Operation and Maintenance.
   Development of applications and systems that have been made at this stage is carried out to improve quality and perform maintenance on the system so that the system can run more optimally.

C. Data Retrieval

The data retrieval technique conducted in this study uses direct observation techniques. The data used is data that is already in the OpenCV library, namely mediapipe which has a model of hand landmarks that operate in the area of the image that has been trimmed and that has been determined by the palm detector and returns a 3D hand keypoint with high fidelity that will form bone line points. on the finger of the right hand. So researchers only need to import a function to detect the gesture pattern of the fingers of the virtual painter user.

D. Data Processing

The data processing technique carried out in this study has several steps to get the desired output, namely by capturing the movement of the right hand finger pattern gestur that will be read by the hand tracking library, namely mediapipe to get gestures that will later be used by virtual painters. On an active camera, the virtual painter will capture the movement of the fingers, if the gesture of the fingers of the fingers forms a predetermined pattern then the virtual painter will perform the function in accordance with the commands given on each movement of the pattern, for pattern one that is by showing one index finger to start the drawing function, for pattern two by clenching the finger segment of the hand to get The function moves freely and selects colors without drawing, for the third pattern by showing five fingers on one hand with a wide open position to get the function of removing.

RESULTS AND DISCUSSION

A. Requirement Analysis

For this stage, the researcher prepares what is needed in the creation of a virtual painter in accordance with the planning set by the researcher. From the planning that has been

made by researchers, there are several things that must be prepared, namely:

1. Virtual painter can be used to detect gesture patterns of finger segments on the hand to be able to draw on the camera
2. Virtual painters can perform drawing and removing functions at the time of use

B. Requirement Definition

After making the necessary preparations in the creation of virtual painters, it will be continued with the creation of restrictions and formats used to be able to meet the needs of planning:

1. Virtual painters will be designed and built using the Python programming language.
2. Virtual painters that have been created will be tested using a research camera.
3. Virtual painter only has a function to detect gesture patterns so the hand to draw and delete.
4. The creation of a virtual painter of finger segment detection using libraries from OpenCV, namely mediapipe and numpy.
5. Creating a virtual painter using openCV libraries numpy and hand tracking module.

C. Design Prototyping

After elaborating on the planning of virtual painter needs and providing limitations in making virtual painters, then researchers will carry out the process of making prototypes for simple user interfaces that had previously been planned by researchers. The design will be simple and focused on function. Here is a draft overview of the virtual painter's display that has been created by researchers:

Figure 2. Overview Menu Virtual Painter

In Figure 2 is an image of what will be seen by the user when opening the virtual painter, a simple shaped display with a button that if the user presses the "Yes" button, then the user will be directed to the virtual painter, and if the user presses the "No" button, then the user It will come out of the virtual painter.
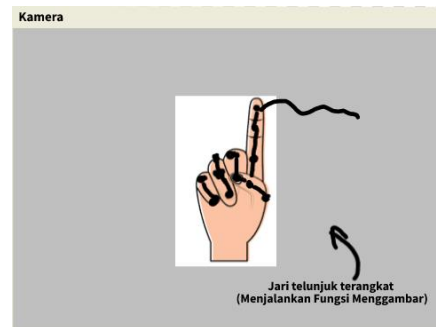

Figure 3. Overview Drawing Function

In Figure 3 is a manual image that will be seen by the user when it is in the virtual painter, in Figure 3 can be seen the shape of a hand pattern in the shape of an index finger raised and others clench, which makes the user will be able to perform the function of drawing on the virtual painter.
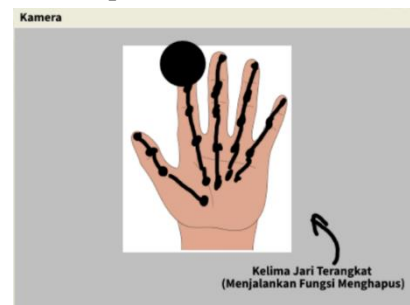

Figure 4. Overview Delete Function

In Figure 4 is a manual image that will be seen by the user when it is in the virtual painter, in Figure 4 can be seen the shape of the hand pattern in the form of five fingers raised and the other clenched, which makes the user will be able to perform the function of removing on the virtual painter
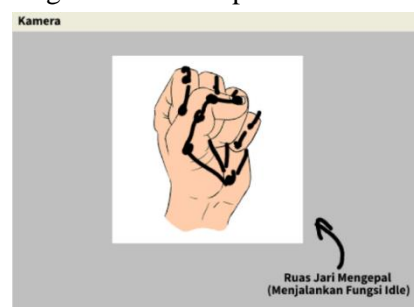

Figure 5. Overview Idle Function

In Figure 5 is an image of what will be seen by the user when it is in the virtual

painter, in Figure 5 can be seen the shape of a hand pattern that is in the form of five fingers close like a fist, which makes the user will be able to perform idle function on the virtual painter, which means the user Can free roam to be able to draw at other position points on the frame.

D. Architecture and Component Design

In the process of this stage the researcher creates a use case that serves as an explanation of the interaction of virtual painter and user functions, here is a use case diagram that has been described by the researcher:
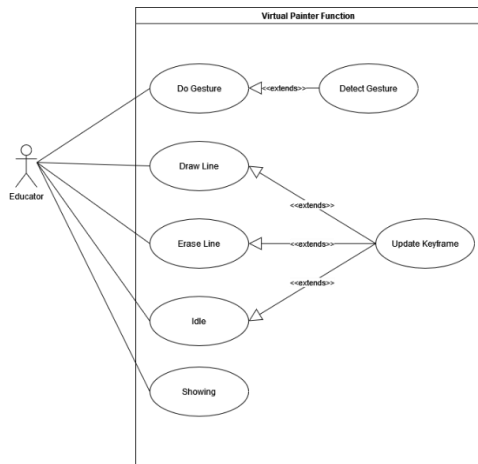
Figure 6. Use Case Diagram

There are 7 use cases and one actor is an educator, educators here only interact directly with 5 use cases only, namely gestures, drawing lines, removing lines, Idle, and displaying what is described by educator actors, 2 other use cases that detect gestures and keyframe updates are part of 5 use case functions that relate directly to actors.
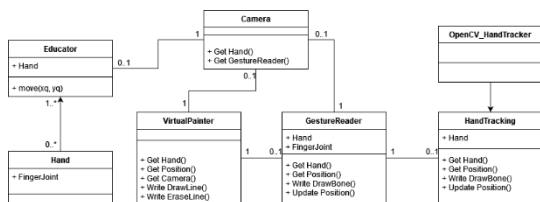

Figure 7. Class Diagram

Class diagram of a virtual painter whose function describes the relationship between one class and another class. In Figure 7 can be seen virtual painter has 7 classes, namely educators, hands, cameras, virtualpainter, gesturereader, handtracking,

OpenCV_HandTracker. And each class has its own attributes and operations in each class.

E. Architecture and Component Prototyping

In this stage process, researchers create an activity diagram that is used to describe the process flow of the function in the virtual painter. Here is an activity diagram that has been created by researchers:
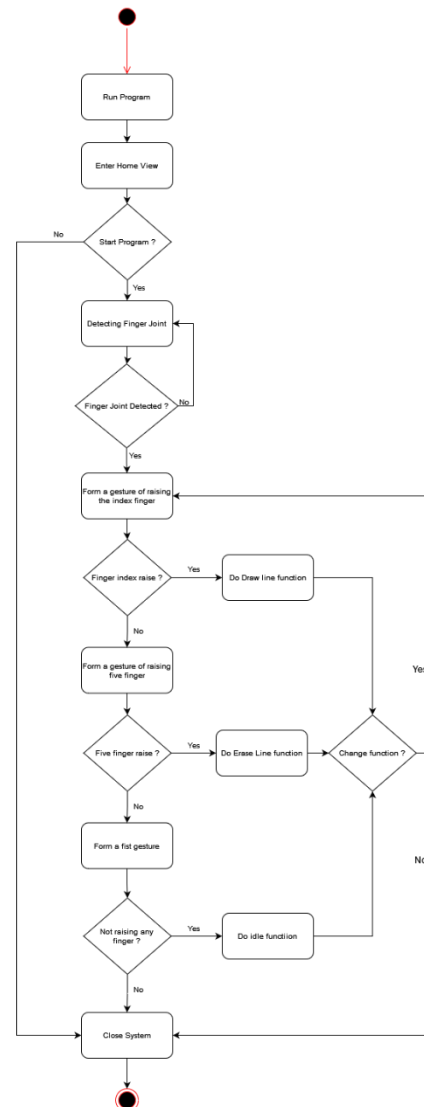

Figure 8. Activity Diagram

Figure 8 is an explanation of the overall activity flow of the virtual painter from the beginning of opening the virtual painter, performing the function of drawing, deleting, Idle and closing the virtual painter.

F. Implementation
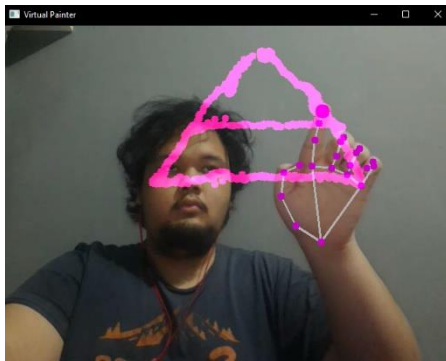
1. **Drawing Function**

Figure 9. Drawing Function

Figure 9 it can be seen that the display when using the drawing function on the virtual painter, where when entering the virtual painter then the virtual painter will detect the gesture pattern of the hand and also automatically if the hand gesture forms a raised index finger and others clench, then the virtual painter Will carry out the function of drawing with the appearance of a pink dot on the tip of the index finger.

```
if up[0] == False and up[1] and up[2] == False and up[3] == False and up[4] == False:
    print("Drawing Mode")
    xp, yp = 0, 0
    cv2.circle(img, (x1, y1), 10, drawColor, cv2.FILLED)

    if xp == 0 and yp == 0:
        xp, yp = x1, y1
```

Figure 10. Drawing Function Line Code

Figure 10 is a line code to determine whether the user's finger gesture pattern that is read is a raised index finger and the other is a clenched fist. If the conditions are met, the virtual painter will run the drawing function and make a thick dot on the index finger as a brush for drawing, the color of the brush will be adjusted according to the line code in Figure 10. Every time the user updates the position when showing the gesture pattern to draw, the virtual painter drawing function will update the position point where the user starts showing his gesture.
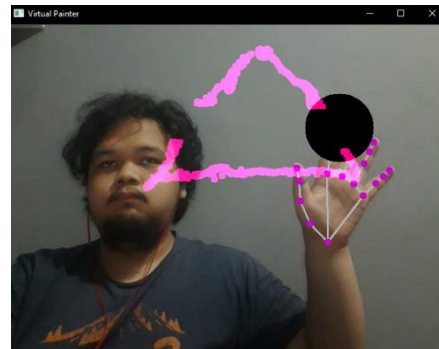
2. **Delete Function**

Figure 11. Delete Function

Figure 11 it can be seen that the display when using the delete function on the virtual painter, where when entering the virtual painter then the virtual painter will detect the gesture pattern of the hand and also automatically if the hand gesture forms five fingers on one hand raised, then the virtual painter will perform the function of removing with the appearance of a large black dot on the tip of the index finger.

```
if up[0] and up[1] and up[2] and up[3] and up[4]:
    print("Eraser Mode")
    xq, yq = 0, 0
    cv2.circle(img, (x1, y1), 50, eraserColor, cv2.FILLED)

    if xq == 0 and yq == 0:
        xq, yq = x1, y1
```

Figure 12. Delete Function Line Code

Figure 12 is a line code to determine whether the user's finger gesture pattern that is read is five fingers on one raised hand. If the conditions are met, the virtual painter will run the erase function and make a thick point on the index finger as a brush to erase, the color of the brush will be adjusted to the line code in Figure 12 which is black. Every time the user updates the position when showing the gesture pattern to delete, the virtual painter delete function will update the position point where the user starts showing his gesture.
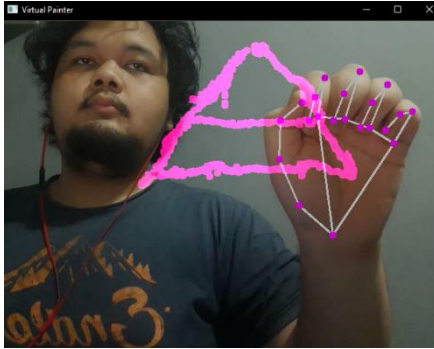
3. Idle Function

Figure 13. Idle Function

Figure 13 it can be seen that the display when using the Idle function on the virtual painter, where when entering the virtual painter then the virtual painter will detect the gesture pattern of the hand and also automatically if the hand gesture forms five fingers on one clenched hand, then the virtual painter will run the Idle function. Idle function is useful for users can move their hands anywhere without having to delete or draw existing objects, and do not interfere with other objects when they want to change the position of the hand.

Figure 14. Idle Function Line Code

Figure 14 is a line code to determine whether the user's finger gesture pattern that is read is five fingers on one clenched hand. If the conditions are met the virtual painter will run the Idle function and every time the user updates the position when showing the gesture pattern for Idle then the Idle function virtual painter will update the position point where the user starts showing his gesture.

4. Home View

Figure 15 Home View

Figure 15 is the initial display when the virtual painter is opened, there is an opening sentence at the top and there are two buttons at the bottom that if the user chooses the "Yes" button then the user is directly directed to the main function on the virtual painter and directly performs the function in the virtual painter and if the user chooses the "No" button then the virtual painter window will be closed.

CONCLUSION AND SUGGESTION

In this study, the conclusions that can be drawn are shown to answer the formulation of the problem that exists in the research of making this virtual painter, namely to answer the formulation of problem number one which reads "How can the virtual painter detect the movement of the finger knuckles pattern on the right hand?" the answer is that the virtual painter function can detect hand movement and can also detect the shape of the hand pattern well. In the second problem formulation which reads "How can a virtual painter be run in real-time?" the answer is that the virtual painter function can detect the finger knuckle gesture pattern on the hand in real-time. In the formulation of problem number three which reads "How can educators use the drawing, erasing, idle and hand tracking functions in the virtual painter?" the answer is in a test that has been run by the user, namely the User Experience Questionnaire which has an efficiency scale that has a positive evaluation. In the formulation of problem number four which reads "How can a virtual painter be a medium to support online learning and teaching activities?" whose answer is very interesting and very appropriate to be used as a medium to support learning and teaching activities and also the results of the overall average scale that has been combined that the virtual painter evaluation has a positive impression of all six scales namely attractiveness, efficiency, clarity, precision, stimulation, novelty.

The advice that can be given in this study is for further research for virtual painters can be used in addition to being a medium of education, it can also be a medium for the world of work when doing work activities from home and can also be a medium of interaction for people who experience speech speech to be able to communicate by describing what they want to convey to the other person when meeting on a regular basis.

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