Hand motion tracking based on gesture understanding using leap gesture for virtual 3D batik gallery

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Abstract. Virtual batik 3D gallery is designed as one of the efforts utilizations of digital-based on media for Industrial Revolution 4.0 where the flow of globalization is becoming sophisticated which emphasizes the digital economical pattern, artificial intelligence, big data, robotic. This research emphasizes on hand motion tracking based scientific knowledge on Gesture Understanding using Leap gesture for the 3-Dimensional Virtual Batik Gallery. Gesture-understanding based on Hand Motion Tracking which advocates Leap Gesture for a 3D Virtual Batik Gallery functions as an interactive virtual media replacing part of the functions Keyboard and Mouse process. This is aimed at varying the media packaging, especially for information providers in terms of how they can relay the information quickly to others, designing application, or documenting data. The method used in this research is Design and Development (D&D) and required three steps involving the process of modelling the initial design (3D modelling) using Normal Map technique, the process of making gesture scenario in the form of FSM in every room, and gesture design using hand motion tracking in Leap Motion controller. The result of the study was in the forms of responses to hand motion tracking in a 3D batik gallery, which was grouped into 3 hand-gesture-understanding concepts: Tap Gesture with motion response description for GPU (16 mm /s 60 FPS), (10 mm /s 100 FPS), ( 5 ms/ 200 FPS), CPU (33 ms 30FPS ), and (16 ms / 60 FPS); for describing and detecting Flyhand Gesture on GPU (16 mm /s) (60 FPS10 mm / s) (100 FPS5 m/s 200 FPS) on CPU (33 ms/ 30FPS) (16 ms / 60 FPS); for Trusther in (GPU = 16 mm /s) ( 60 FPS33mm / s ) (100 FPS16 ms 60 FPS) CPU (33 ms 30 FPS 10 ms ) (60 FPS 33 ms 5 ms 200 FPS); and for Hold Hand Gesture on CPU (33 ms 30 FPS) (66 ms 60 FPS) and the response on GPU (33 ms 30 FPS) (66 ms 60 FPS).

1. Introduction

Hand Motion Tracking is a term for the act of recording something using hand motion, which is used as a digital model intended as an alternative in using hand motion to create an impression of natural interaction between human beings and computers. Some of the realizations of hand motion tracking are the utilization of gesture in motion tracking, as a system of recognizing a language (gesture recognition), the making of 3D animation, motion capture, natural user interface, and so forth. Pavlovic stated, in his journal Visual Interpretation of Hand Gestures for Human Human-Computer Interaction: A Review, that the use of gesture as a 3D-based interactive model for human-computer interaction can basically be one of the ways to improve the comfort in the process of communication between a human and machine, in which the concept of developing gesture has been beyond the limit of room and form, so it is
illimitable [1]. Visual interpretation of natural hand motion has been the cornerstone of interacting with machine in our everyday life. For instance, the use of mouse and keyboard is prevalent among people in interacting with computers with ease. Nevertheless, since the advances of technology trigger and require more sophisticated human-computer virtual interaction needing user-oriented interaction and comfort, today's interaction is deemed confined and less natural [2]. Related the previous research, users need more natural methods of interaction and communication between users and computers because this is one of the demands of technological development. Interaction methods in Virtual Reality, Wearable Computer, and Augmented Reality applications suggest the traditional interaction devices such as the keyboard, mouse and joystick are no longer comfortable to use [3]. Leap Motion software works by detecting hands, fingers in certain areas, then the detection results are processed based on objects with orientation and movement in the frame rate of Leap Motion [4].

Related the previous research about Batik, Development of Indonesian batik design is a strategic step to strengthening identity and advantage of Indonesia creative industry besides to preserving cultural heritage [5]. The terminology behind batik crafting and showed the aspects of self-similarity in its ornaments. Even though a product of batik cannot be reduced merely into its decorative properties but it is shown that computation can capture some interesting aspects in the batik-making ornamentation. Even though the computation will never be able to replace the process of batik crafting as well as, but most importance, the corresponding aesthetical aspects, the computationally generative batik ornaments has shown us that the meeting of traditional crafting and modern computation could lead us to the unlimited creativity. A thing that is so much demanded by our nowadays-economic system [6]. A challenge to meet the modern computational generative art with the traditional batik designs is expected to yield synergistically interesting results aesthetically. In addition to that, the technological advances and their advantages in virtual media have been achieved, appearing as a media of information and communication [7].

Some of the realizations are the use of virtual media to document a work, information in the form of 2D media using keyboard and mouse to control the media functioning to convey a message and provide information about batik [8], and the use of Eco-Color interactive Multimedia (ECMi) in a courseware as the media which provides information on traditional batik through superb videos, audios, pictures, and illustrations, and, thus, is suited to teaching and learning the art of painting and drawing [9]. Marini stated in his research the ability of students to use the gallery walk method higher than the ability of students without a Gallery Walk. This is indicated by the difference in the acquisition of the average value of the control and experimental classes, respectively, namely control 70.5 and experiment 83.5. His is also demonstrated through the results of inferential statistical analysis with the Paired Sample Test system [10].

The study aims to develop Hand-Gesture based Motion Tracking using Leap Gesture for a 3D virtual Batik Gallery and to design an interactive virtual system to replace keyboard and mouse to run the batik gallery application. The result of the study can be another innovation in information technology and graphic computer, especially for those providing information in speedily sending information, designing applications, or documenting data.

A virtual Batik Gallery is designed to be an information media becoming one of the alternatives to provide information, document work products, or be an interactive media in designing batik virtually advocating hand motion tracking in leap motion controller.

2. Research method
The method used in this research is Design and Development (D&D) [11] and required three steps involving the process of modelling the initial design (3D modelling) using Normal Map technique, the process of making gesture scenario in the form of FSM in every room, and gesture design using hand motion tracking in Leap Motion controller.

Based on Handbook of Virtual Environments, the principles required to define system include design, build, evaluate, implement, and manage the effective use of Virtual Environment applications [12].
Figure 1. D&D method.

Interface design with touchless method was conducted by means of modifying the 'event' result from mouse and keyboard by initializing every command in the computer into data, which is Leap-gesture readable.

Figure 2. Hand gesture design with Unity3D for 3D virtual batik gallery.

As can be viewed in figure 1, in the making of a 3D Gallery, the 2D motif processing in room 2 is divided into three stages: the making of pre-design batik called kelowong, the process of isen-isen batik motif, and the process of coloring the motif of batik (see Figure 2). In the Kelowong and Isen-isen phases, the researcher used GUI camera in Unity3D; in this process leap motion controller with its touchless program read it.

Figure 3. Processing bitmap pattern (a) Mega Mendung pattern (b) Parang Rusak pattern and (c) Sidomukti pattern.

Furthermore, to attain a 3D object, Normal Map was used to create textures and materials with 3D effects. Additionally, for 3D interior design, it was necessary to give the wall and floor textures, too, by making planes on a primitive mess object on a scale (of X: 10, Y: 10, Z: 10). Moreover, the rotation on the wall was on a scale of X: 270, Y: 0, and Z: 0, and the wall working as the separator was on a scale of X: 0.5, Y: 10, Z: 10 (as can be seen in Figure 3).
2.1. *First Person Shooter (FPS) for mouse and keyboard in a 3-Dimensional batik gallery*

The technique of First-Person Shooter in Standard Asset Unity 3D used a camera controller perceptively set to manage a 3D Batik Gallery (see Figure 4). In addition, the Library used for controlling applications in the Gallery were Mouse Lock and Character Motor Script working as the application controllers using keyboard joystick or other devices.

2.2. *Interaction scenario for a 3-Dimensional batik gallery*

In the hand gesture scenario, the researcher used the so-called Finite State Machines (FSM) to design controlling system illustrating how gesture worked in a 3D virtual Batik Gallery by considering three aspects, i.e. state, event, and action, consisting of Room 1 for the first menu, Room 2 for the Batik motif, and Room 3 for Batik exhibition. The design of interaction can be describing as follows.

2.2.1. *Space 1.* Space 1 contains the main menu that interactively helps users select and control which available applications they want to choose. Figure 5 demonstrates the gesture interaction consisting of menu interaction for entering the space, another interaction for choosing the motif in space 2, and the other interaction for the gallery in space three.
2.2.2. Space 2. Space 2 provides users a motif menu interaction functioning as an object, which can be run using mouse and a touchless system, as a form of a gesture interaction in the creation. The gesture interaction in Figure 7 is used to choose the motif for pre-designing including Kelowong and Isen-isen or motif coloring.

![Figure 7. The scenario for room 2.](image)

2.2.3. Space 3. The third space is a place for a virtual Batik gallery. The gallery was two- and three-dimensionally designed to display all Batik motif and products. Also, the researcher used the Normal Map technique for the interior design to show the texture and dimensional effect of the object. The realization of the gesture is used to control the overall interaction processes of browsing and exploring the rooms (see figure 8).

![Figure 8. The scenario for room 3.](image)

2.3. The use of GUI camera unity 3D for a navigation button

2.3.1. The button of batik motif, kelowong batik, and isen-isen batik. GUI in Unity3D camera is used for assisting the users in choosing buttons available in the menu. Some designs were demanded, such as intro for entering the room in the first window and navigation in the application was necessary buttons to help gesture control and choose the providing interactions. The researcher then employed the two-dimensional Cartesian coordinate system generally illustrated by two axes: vertical and horizontal axes (X and Y) (see Figure 8).
In the design of Room 1, the position of navigation button in Unity3D camera can be described by figure 8 which explanation is as follows.

- A Batik Room Button
  
  (X: 550, Y: 300, X: 60, Y: 60)

- A Three-dimensional Gallery Button
  
  (X: 550, Y: 380, X: 60, Y: 60)

- An Exit Button
  
  (X: 1200, Y: 500, X: 80, Y: 50)

In space 2, the gesture interaction needed is tap gesture previously designed as a navigation button application in Unity3D camera. The buttons involve gesture interactions for Mega Mendung, Parang Rusak, and Sidomukti motifs (see the button positions in Figure 9).

- Mega Mendung Motif Button
  
  (X: 20, Y: 20, X: 100, Y: 50)

- Kelowong Motif Button
  
  (X: 140, Y: 20, X: 100, Y: 50)

- Isen-Ise Motif Button
  
  (X: 260, Y: 20, X: 100, Y: 50)

In space 2, the gesture interaction needed is tap gesture previously designed as a navigation button application in Unity3D camera. The buttons involve gesture interactions for Mega Mendung, Parang Rusak, and Sidomukti motifs (see the button positions in Figure 9).
- Parang Rusak Motif Button  
  (X: 20, Y: 100, X: 100, Y: 50)  
- Kelowong Motif Button  
  (X: 40, Y: 100, X: 100, Y: 50)  
- Isen-Isen Motif Button  
  (X: 260, Y: 100, X: 100, Y: 50)  
- A Sidomukti Motif Button  
  (X: 20, Y: 180, X: 100, Y: 50)  
- Kelowong Motif Button  
  (X: 140, Y: 180, X: 100, Y: 50)  
- Isen-Isen Motif Button  
  (X: 260, Y: 180, X: 100, Y: 50)

2.3.2. The button of motif color. The design of color button for Batik motif is used to make the users easily choose any colors provided by the previous design using mouse, and then improved to be readable in Touchless program of Leap Motion Controller. The colors involve red, blue, yellow, and green. The object processing in Unity3D associated with the interaction position management of the color button is illustrated in Figure 10. With the following explanation.

- The Blue Button (X: 350, Y: 600, X: 80, Y: 40)  
- The Red Button (X: 450, Y: 600, X: 80, Y: 40)  
- The Yellow Button (X: 550, Y: 600, X: 80, Y: 40)  
- The Green Button (X: 650, Y: 600, X: 80, Y: 40)

3. Results
This study tested the design of hand motion tracking for gesture understanding using the Leap Motion Controller for controlling virtual batik Gallery, which aims at determining whether the function has been well implemented. Two kinds of test used in this research; functional testing and action response speed test system for a given gesture.

3.1. Functional testing
The first test is to test the usefulness of each design Hand gesture for any 3-dimensional space, as well as the results of interactions that have been scripted as the response in every space.

3.1.1. Leap gesture interaction for space 1. The scenario space interactively can help users to select and control the applications provided. The menu provided for users include interaction for enter the first room, predesign interaction motif in the interaction chamber 2 and 3 for exhibition space in the gallery Virtual Batik.

In room 1, Tap gesture is used to select the button to the user interaction with the system. Below in figure 11, have described the data obtained in the frame Leap Touchless Gesture to the system.

![Figure 11. Gesture testing with Samsung NP355v4X- A02ID.](image-url)
In figure 11. Testing of finger movements using touchless as testing facilities for Leap Motion detection response controller using Samsung laptop NP355V4X-A02ID, where the results of the test response to be a reference for designing hand gesture for 3D Virtual Gallery. Leap Motion software works by detecting hands, fingers in certain areas, then the detection results are processed based on objects with orientation and movement in the frame rate of Leap Motion \[4, 13\]. Based on the journal entitled *The Molecular Control Toolkit: Controlling 3D Molecular Graphics via Gesture and Voice*, leap motion system work by connector built in leap motion antranslated and detected in 3D for one hand leap motion connector supports direct mouse and mouse movement by controlling the display of the monitor by using gestures for finger points. This event is used to move the screen / monitor screen which is simulated by mouse press movement and release event so that users can connect data using the mouse \[14\].

The design and visualization design space were designed using Unity3D game engine, with a caption for the visualization of the gallery can be described in Figure 12.

**Figure 12.** Space 1 visualization.

Room design made from 8 Cube for wall, floor and roof for each room in which each function of the cube of the mess was completed in texture size and material objects that are stored in the Library Unity3D. For button in each room, navigation was made using Cartesian coordinates and controlled by camera in Unity3D.

- room in gallery button
  (X: 550, Y: 300, X: 60, Y: 60)
- gallery 3D button
  (X: 550, Y: 380, X: 60, Y: 60)
- exit button
  (X: 1200, Y: 500, X: 80, Y: 50)

3.1.2. *Leap gesture interaction for room 2.* The Interaction for this room includes interaction motif menu by using mouse and the system as a form of touchless gesture interaction in the creation.

**Figure 13.** Space 2 visualization.
Visualization design can be described in Figure 13. The design space consists of four cubes mess that has been made using materials and textures in the library Unity3D. The button interaction motif attaches a button consisting mega mendung motif, Parang rusak motif and sidomukti motif, in which each of the motif test has 3D interaction, including kelowong motif facilities, Isen motif button, and color button selection.

Button positions are created in each coordinate in Figure 13. Visualization used as the button motif for reference for making interactions using the mouse, so it will be a reference in the use of gesture for touchless system. The following results for room 2 are translated to the position coordinates of the button design,

- Mega Mendung button
  (X: 20, Y: 20, X: 100, Y: 50)
- Button of Kelowong motif
  (X: 140 Y: 20, X: 100, Y: 50)
- Button of Isen-Isen motif
  (X: 260 Y: 20, X: 100, Y: 50)
- Button of Parang Rusak motif
  (X: 20, Y: 100, X: 100, Y: 50)
- Kelowong motif button
  (X: 140 Y: 100, X: 100, Y: 50)
- Button of Isen Isen motif
  (X: 260 Y: 100, X: 100, Y: 50)
- Button of Sidomukti motif
  (X: 20, Y: 180, X: 100: Y: 50)
- Kelowong motif button
  (X: 140 Y: 180, X: 100, Y: 50)
- Process button of Isen Isen motif
  (X: 260 Y: 180, X: 100, Y: 50)

Furthermore, the results of visualization were tested for response to gestures using Leap Motion Controller with response to tap gesture interaction.

| Testing | Motif Name       | Interaction            | Motif Color |
|---------|------------------|------------------------|-------------|
| 1       | Mega Mendung     | 16 ms/ 60 FPS          |             |
| 2       | Parang Rusak     | 16 ms/ 60 FPS          |             |
| 3       | Sido Mukti       | 16 ms/ 60 FPS          |             |

Table 1. Interactions response gesture.

Table 1 describe the result of test for Tap gesture consists to 3 motif button which each key motif has the process of Kelowong motif and process of Isen Isen motif and every interaction motif button has color button facilities, include of red, blue, yellow and green color. The results of each response obtained Gesture Tap the same responses, which is 16 ms / 60 FPS.
3.2. 3 leap gesture interaction for gallery

Gallery was designed to showcase all the work of batik motif with Normal maps technique to show texture and dimension effect for each object. Textures and shades of the wood material has shown in Figure 14.

![Figure 14. Visualization for interior gallery.](image)

The results of the use Fly Hand, Trusther and hold hand for controlling gesture in virtual gallery described in Table 2.

| CPU | GPU | Description |
|-----|-----|-------------|
| 16 mm/s (60 FPS) | 33 ms (30 FPS) | Fly hand |
| 10 mm / s (100 FPS) | 16 ms/ 60 (FPS) | |
| 5 ms (200 FPS) | |
| 16 mm/s (60 FPS) | 33 ms (30 FPS) | Trusther |
| 33 mm/s (FPS) | 10 ms / (60 FPS) |
| 16 ms 60 (FPS) | 33 ms |
| | 5 ms / 200 (FPS) |
| | |
| 33 ms (30 FPS) | 33 ms (30 FPS) | Hold hand |
| 66 ms (60 FPS) | 66 ms (FPS) |

Based on table 2 the results of response fly-hand gesture for CPU when leap gesture is used as a device controller mouse and keyboard replacement application is 5 ms / 200 FPS, 10 mm / s 100 FPS and 16 mm / s 60 FPS, for fly hand response to GPU is 16 ms / 60 FPS and 33 ms / 30 FPS, for fly hand Response to the CPU when Leap gesture is used as a device controller mouse and keyboard replacement application is 5 ms / 200 FPS, 10 mm / s 100 FPS and 16 mm / s 60 FPS. Furthermore, for Thruster response for CPU is 16 ms / 60 FPS and 33 ms / s 100 FPS, hold hand gesture for GPU and CPU is 33ms / 30 FPS, 66 ms / 60 FPS.

3.3. Speed testing

Testing was done by recording the process of detection for hand motion tracking and the duration of interaction process in room 1, room 2, and room 3. Continuously, a transition occurs during the recording movement of the hand and the transition time will be counted as time lag gesture. Results of testing of each device can be seen in Table 3, Table 4 and Table 5.

| Testing | Tap Gesture |
|---------|-------------|
|         | CPU         | GPU         |
|         | min         | max         | min         | max         |
| Space 1 | 13 ms / 60FPS | 33ms/60 FPS | 13ms/ 60 FPS | 33 ms / 30 FPS |
| Space 2 | 16 ms / 60 FPS | 33 ms / 30 FPS | 10 ms / 60 FPS | 16 ms/60 FPS |
| Space 3 | 13 ms / 60 FPS | 33ms/60 FPS | 13ms/ 60 FPS | 33 ms / 30 FPS |
Table 3, in average, the results of response for interaction tap gesture in the gallery. For room 1, the minimum obtained from the CPU and GPU is 13 ms / 60 FPS, the second space tap gesture on the response speed of the CPU obtained the minimum value is 16 ms / 60 FPS, and the maximum is 33 ms / 60 FPS, while the response for tap gesture within the GPU and the CPU obtained a minimum of 10 ms / 60 FPS, and a maximum of 16 ms / 60 FPS. For response speed 3 gesture in space for CPU and GPU are the same, at least 13 ms / 60 FPS, and a maximum of 33 ms / 60 FPS.

**Table 4.** Testing results for response rate gesture interaction in room 2.

| Testing | Motif Name   | Interaction | Motif Color |
|---------|--------------|-------------|-------------|
|         | Kelowong     | Isen        |             |
| 1       | Mega Mendung | 16 ms/60 FPS| 16 ms/60 FPS|
| 2       | Parang Rusak | 16 ms/60 FPS| 16 ms/60 FPS|
| 3       | Sido Mukti  | 16 ms/60 FPS| 16 ms/60 FPS|

The Response average for tap gestures interaction in room 2 obtained from the CPU and GPU is 16 ms / 60 FPS.

**Table 5.** The results for response gesture interaction in room 3.

| Testing | Interaction Name | Interaction Response |
|---------|------------------|----------------------|
|         | Flyhand Right    | Flyhand Left         | Hold |
| 1       | Walking          | Max 66 ms / 15 FPS   | Max 66 ms / 15 FPS |
| 2       | Turn Right and left | Max 66 ms / 15 FPS | Max 66 ms / 15 FPS |
| 3       | Stop             | Max 33 ms / 30 FPS   |      |

Table 5, response for the speed of gesture interaction to turn left and turn right in the gallery for each interaction has maximum 66 ms / 15 FPS, while the interaction stops in room 3, it was found that the maximum speed is obtained 33 ms / 30 FPS.

4. Conclusion

Visual interpretation of natural hand motion has been the cornerstone of interacting with machine in our everyday life. For instance, the use of mouse and keyboard is prevalent among people in interacting with computers with ease. Nevertheless, since the advances of technology trigger and require more sophisticated human-computer virtual interaction needing user-oriented interaction and comfort, today's interaction is deemed confined and less natural.

This study required three steps involving the process of modelling the initial design (3D modelling) using Normal Map technique, the process of making gesture scenario in the form of FSM in every room, and gesture design using hand motion tracking in Leap Motion controller.

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