A Study of Elementary Students' Controlling on Leap Motion

YANG-TING CHEN, MIAO-KUEI HO, HUNG-JEN YANG

Abstract**—**the purpose of this study was to verify the feasibility of using Gesture control on computer free- hand drawing in an educational environment for elementary students. A gesture control device, Leap Motion was selected for this study. Some API reference of Leap motion would be introduced such as Gesture, Controller, frame and fingers. A field hands-on experiment environment was established for elementary students. The procedures of the hands-on experiment were 1).introducing the hardware and software used in the experiment, 2).video recording students' hand-movement of using Gesture control device and drawing results on the computer, 3) recoding the operating time for statistical analysis. The experimental results and statistical evidence suggested the gesture control could be handled by elementary in free-hand drawing. The average operating times and operating stability were also concluded.

Keywords**—** Gesture Control, Leap Motion, Elementary Student

I. Introduction

IN this Information Age, learners have at their enormous amounts of learning activities experienced the information computer technology, ICT, used in the educational environments. These ICTs are designed for the well-organized selection, storage, and retrieval of data, and are vital for learners to construct and keep track of their knowledge formations. All the ICT instruments require communicate users with certain input and output devices. During these years, more and more gesture control device such as Kinetic, Leap motion, and Myo etc. had been designed and produced. They are the newest technology can be seen as a way for computers to begin understanding human body language, like building a bridge between machines and humans, there is a need to explore their feasibility of learning environment. In this study, the selected gesture control device was named "Leap motion". The purpose of this study was to verify the feasibility of Gesture control used by elementary students. An experiment was designed for the twelve grade-sixth students. Participants were asked to do free-hand drawing. Based upon those hands-on operating procedures, the details operations of gesture control devices were recorded for review. Based upon those evidence revealed, the feasibility of the gesture control device was identified.

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Y. T. Chen is with the National Kaohsiung Normal University, 80201 Taiwan, R.O.C. (e-mail: tbes355254@gmail.com)

M. K. Ho is with the National Kaohsiung Normal University, 80201 Taiwan, R.O.C. (e-mail:hmq0402@gmail.com)

H.J. Yang is with the National Kaohsiung Normal University, 80201 Taiwan, R.O.C. (e-mail: hjyang@nknucc.nknu.edu.tw, phone: 886-7-7172930 ext. 7603, fax: 886-7-6051206).

A. *Characteristics of the Leap Motion*

The Leap Motion controller is a small USB peripheral device which is designed to be placed on a physical desktop, facing upward. Using two monochromatic IR cameras and three infrared LEDs, the device observes a roughly hemispherical area, to a distance of about 1 meter (3 feet). The LEDs generate a 3D pattern of dots of IR light and the cameras generate almost 300 frames per second of reflected data, which is then sent through a USB cable to the host computer, where it is analysed by the Leap Motion controller software using "complex math" in a way that has not been disclosed by the company, in some way synthesizing 3D position data by comparing the 2D frames generated by the two cameras. The smaller observation area and higher resolution of the device differentiates the product from the Kinect, which is more suitable for whole-body tracking in a space the size of a living room. In a demonstration to CNET, The Leap was shown to perform tasks such as navigating a website, using pinch-to-zoom gestures on maps, high-precision drawing, and manipulating complex 3D data visualizations.

B. *Advantages of Leap motion*

Leap Motion controller are precise enough to detect all of the movement of ten human finger, it can track pinch, wave or any other motion you can make with your fingers, hands or any other small devices such as pens. There is almost no input lag occurred during usages and works flawlessly. Leap motion controller almost does not require big space for usage, only a tiny piece of hardware, put on the front of the keyboard, and you would not even discover it at a glance. Leap Motion controller can detect the position of your hand and fingers with a precision of 0.01mm within an eight cubic foot volume of space.

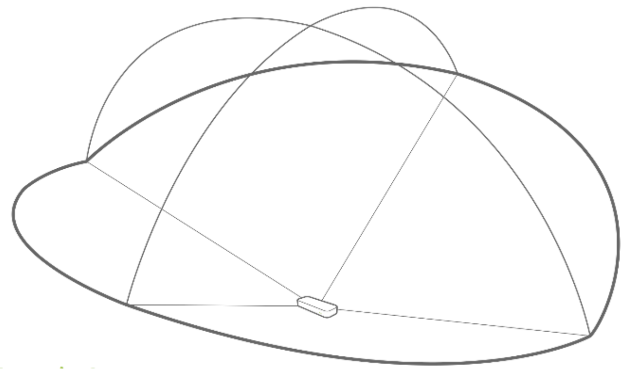


Fig. 1 Interaction area of a Leap Motion device, from Leapmotion.com

To translate this, it means every finger twitching can be detected above the device within a space the size of a 33 inch screen in a square box. Fig. 1 shows interaction area of a Leap Motion controller within an eight cubic foot volume of space

C. Disadvantages of Leap motion

Due to new hardware, Leap Motion still has many bugs, some people still having all kind of accuracy and tracking problems even with the paid apps and with some of them spending hours in order to learn how to use Leap Motion controller. This is why we are going to design a program/ application to help user to get more user-friendly platform to learn gesture control of the controller. With a little more than 85 apps available, despite a software developer program launched in October 2012 that was supposed to get a good number of apps in return, Air Space is seriously struggling to keep up with the demand for more apps, and therefore annoying many users

D. API Reference of Leap motion

1) CircleGesture

The CircleGesture classes represents a circular finger movement.

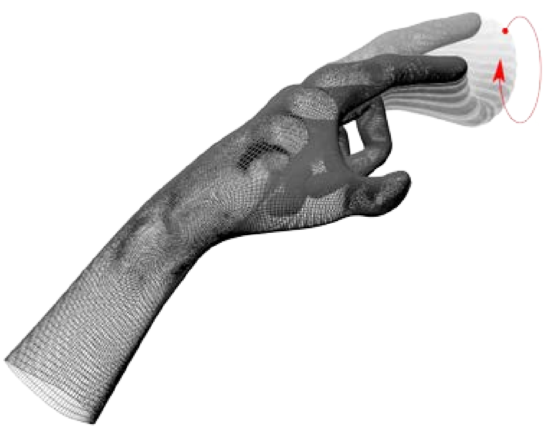


Fig 2 The CircleGesture on Leap motion, from [8] citation

A circle movement is recognized when the tip of a finger draws a circle within the Leap Motion Controller field of view.

2) Config

The Config class provides access to Leap Motion system configuration information.

You can get and set gesture configuration parameters using the Config object obtained from a connected Controller object. The key strings required to identify a configuration parameter include.

3) Controller

The Controller class is your main interface to the Leap Motion Controller.

Create an instance of this Controller class to access frames of tracking data and configuration information. Frame data can be polled at any time using the Controller::frame() function. Call frame() or frame(0) to get the most recent frame. Set the history parameter to a positive integer to access previous frames. A controller stores up to 60 frames in its frame history.

Polling is an appropriate strategy for applications which already have an intrinsic update loop, such as a game.

You can also add an instance of a subclass of Leap::Listener to the controller to handle events as they occur. The Controller dispatches events to the listener upon initialization and exiting, on connection changes, when the application gains and loses the OS input focus, and when a new frame of tracking data is available. When these events occur, the controller object invokes the appropriate callback function defined in your subclass of Listener.

Unless the listener is added to another controller again, it will no longer receive frames of tracking data.

The Controller object is multithreaded and calls the Listener functions on its own thread, not on an application thread.

4) Finger

The Finger class represents a tracked finger.

Fingers are Pointable objects that the Leap Motion software has classified as a finger. Get valid Finger objects from a Frame or a Hand object.

Fingers may be permanently associated to a hand. In this case the angular order of the finger IDs will be invariant. As fingers move in and out of view it is possible for the guessed ID of a finger to be incorrect. Consequently, it may be necessary for finger IDs to be exchanged. All tracked properties, such as velocity, will remain continuous in the API. However, quantities that are derived from the API output (such as a history of positions) will be discontinuous unless they have a corresponding ID exchange.

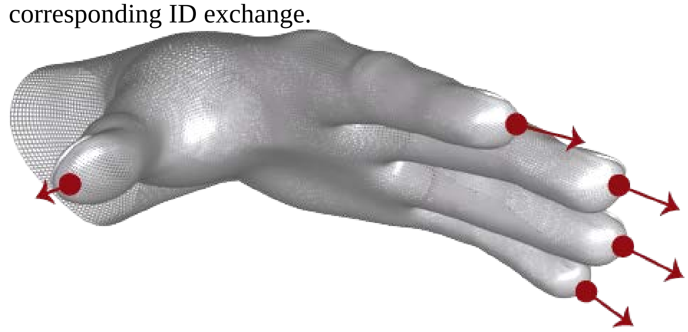


Fig 3 The direction is expressed as a unit vector pointing in the same direction as the tip, from [9] citation

5) Frame

The Frame class represents a set of hand and finger tracking data detected in a single frame.

The Leap Motion software detects hands, fingers and tools within the tracking area, reporting their positions, orientations, gestures, and motions in frames at the Leap Motion frame rate.

6) Gesture

The Gesture class represents a recognized movement by the user.

The Leap Motion Controller watches the activity within its field of view for certain movement patterns typical of a user gesture or command. For example, a movement from side to side with the hand can indicate a swipe gesture, while a finger poking forward can indicate a screen tap gesture.

When the Leap Motion software recognizes a gesture, it assigns an ID and adds a Gesture object to the frame gesture list. For continuous gestures, which occur over many frames, the Leap Motion software updates the gesture by adding a Gesture object having the same ID and updated properties in each subsequent frame.

7) Hand

The Hand class reports the physical characteristics of a detected hand.
Hand tracking data includes a palm position and velocity; vectors for the palm normal and direction to the fingers; properties of a sphere fit to the hand; and lists of the attached fingers and tools.

8) InteractionBox

The InteractionBox class represents a box-shaped region completely within the field of view of the Leap Motion controller.

The interaction box is an axis-aligned rectangular prism and provides normalized coordinates for hands, fingers, and tools within this box. The InteractionBox class can make it easier to map positions in the Leap Motion coordinate system to 2D or 3D coordinate systems used for application drawing.

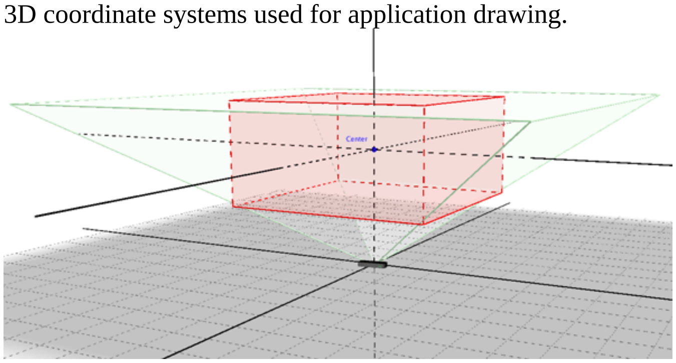


Fig 4 The InteractionBox region is defined by a center and dimensions along the x, y, and z axes, from Leap Motion Python SDK v1.2 documentation [10]

9) Listener

The Listener class defines a set of callback functions that you can override in a subclass to respond to events dispatched by the Controller object.

To handle Leap Motion events, create an instance of a Listener subclass and assign it to the Controller instance. The Controller calls the relevant Listener callback function when an event occurs, passing in a reference to itself. You do not have to implement callbacks for events you do not want to handle.

The Controller object calls these Listener functions from a thread created by the Leap Motion library, not the thread used to create or set the Listener instance.

10) KeyTapGesture

The KeyTapGesture class represents a tapping gesture by a finger or tool.

A key tap gesture is recognized when the tip of a finger rotates down toward the palm and then springs back to approximately the original postion, as if tapping. The tapping finger must pause briefly before beginning the tap.

Fig 5 The KeyTapGesture of Leap motion, from Leap Motion Python SDK v1.2 documentation [11]

11) SwipeGesture

SwipeGesture objects are generated for each visible finger or tool on the swiping hand. Swipe gestures are continuous; a gesture object with the same ID value will appear in each frame while the gesture continues.

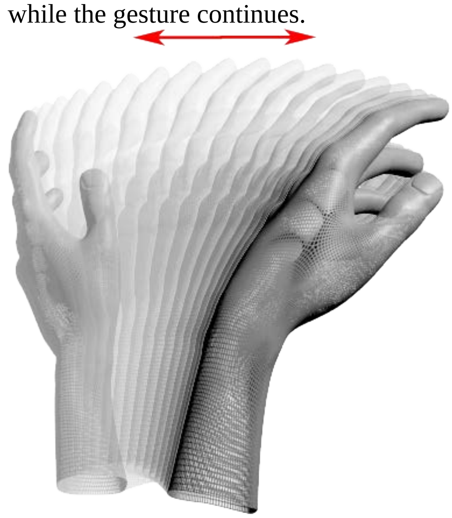


Fig 6 The SwipeGesture class represents a swiping motion of hand and a finger or tool, from Leap Motion Python SDK v1.2 documentation [12]

12) ScreenTapGesture

The ScreenTapGesture class represents a tapping gesture by a finger or tool.

A screen tap gesture is recognized when the tip of a finger pokes forward and then springs back to approximately the original postion, as if tapping a vertical screen. The tapping finger must pause briefly before beginning the tap

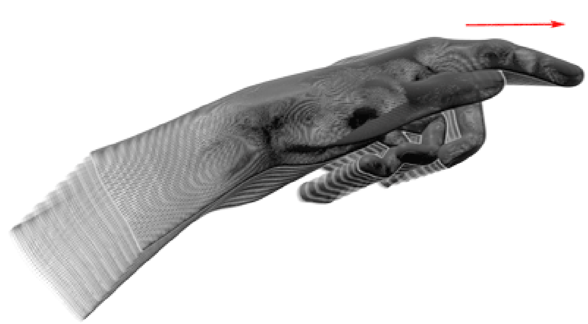


Fig 7 To use screen tap gestures in your application, you must enable recognition of the screen tap gesture, from Leap Motion Python SDK v1.2 documentation [13]

13) Tool

The Tool class represents a tracked tool.

Tools are Pointable objects that the Leap Motion software has classified as a tool. Tools are longer, thinner, and straighter than a typical finger. Get valid Tool objects from a Frame or a Hand object.

Tools may reference a hand, but unlike fingers they are not permanently associated. Instead, a tool can be transferred between hands while keeping the same ID.

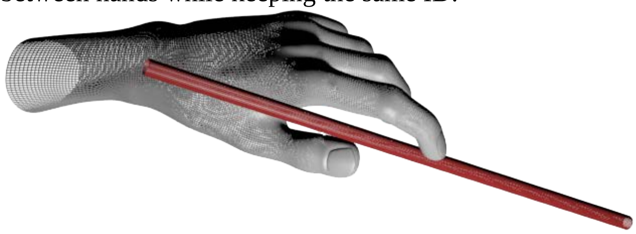


Fig 8 To use tool gesture in your application, from Leap Motion Python SDK v1.2 documentation [14]

II. Problem Formulation

The problem of this is whether the gesture control device, so called Leap Motion, could be handled by elementary students for the purpose of free-hand drawing. For exploring feasibility of this device, an experiment method would be applied in this study. For verifying the feasibility, statistical hypothesis were set up for testing. Those hypothesis are listed as follows.

1) It was hypothesized that participants could use the device to draw a circle in a certain time.
2) It was hypothesized that participants could use the device to draw a cross in a certain time.
3) It was hypothesized that participants could use the device to draw a triangle in a certain time.
4) It was hypothesized that participants could use the device to draw a square in a certain time.
5) It was hypothesized that there exists significant time difference between the first and the second drawing.

Because the Gesture control is a newest technology, it is also an input device like mouse and keyboard, everyone uses these input devices would be different such as accuracy, operability and stability, the difference of using Gesture control would be investigated during the analyzing procedure. The percentage of appropriately operating the gesture control device would be investigated for understanding participants' ability of locating the starting point. Whether these Gesture control devices could be fairly used every users, this is an important feasibility that this study would explore. The operating time period would be collected for studying the feasibility.

III. Experiment Design & Findings

In this session, the experiment design would be reported and findings would be identified according to both the descriptive statistics and hypothesis tests.

A. Experiment Design

In the experiment, the students need to draw four basic pictures, circle, cross, triangle and square. A starting point would be given in the activity. Participants must follow the required order to draw and the path would be displayed on the other screen. In Fig. 1, the clue presented for participants is shown. The software used in the hand-on drawing procedure is Painter® Freestyle™. Painter® Freestyle™ is a revolutionary product integrated with Leap Motion technology, allowing users to paint with their hands, plus access tools and controls without even touching your PC.

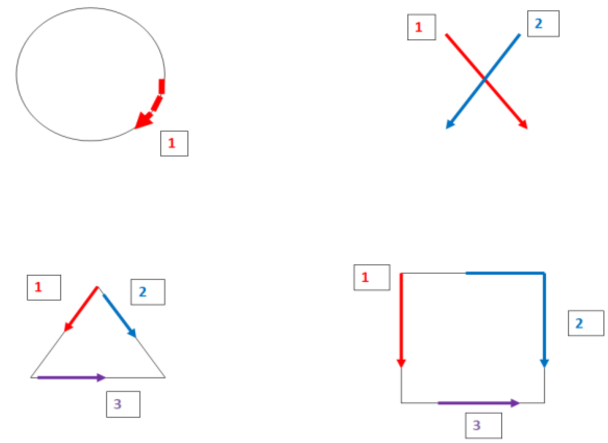


Fig. 9 the order of drawing pictures

At the first, participants would be introduced how to draw a circle in Painter Freestyle on the screen by instructor's demonstrating. Participants would watch the instructor's free-hand drawing operation of each shape, circle, cross, triangle and square, before their own action. The principle of Gesture control and how to control the brush of Painter Freestyle by using Leap motion would not be taught or explained from the beginning till the end.

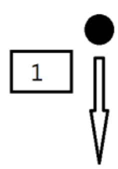


Fig. 10 The starting point

After the demonstration, the experiment would begin. There are 30s for participants to draw every picture. We hope the students won't have a long time to explore the device. They must try to find the sensing range of Leap motion, control the brush, locate the starting point and finish their test according to their instruction. In the Fig.2 the starting point would be display as a reference. In Fig. 3, a participant who is on the left and an instructor who is on the right were conducting the free-hand drawing with the gesture control device, the Leap Motion.

B. Findings

In this session, the finding of experiments would be reported in the following orders:
Overall Drawing Analysis:

a) Raw data of participants' drawing pictures of circle

b) Raw data of participants' drawing pictures of cross

c) Raw data of participants' drawing pictures of triangle

d) Raw data of participants' drawing pictures of square

Locating Analysis: Locating analysis would be done by the Statistical Analysis upon Time

1) Overall Drawing Analysis on circle

In Table 2, the pictures of participants drawing by their free-hand via Leap Motion were shown. Pictures in the same row were belong to the same person and were drawn in two different times. There are notable characteristics:

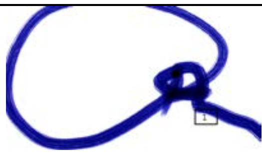
a) For the same person, the shape of two pictures is similar.

b) Only one case out of twelve is shown that well shape in the first drawing and out of control in the second drawing.

c) Only on case out of twelve is shown that out of control in the first drawing and getting the shape in the second drawing

Fig. 11 Students' drawing experiment

Table 1 raw pictures of drawing Circle

No	Test1	Test2
1		
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4		
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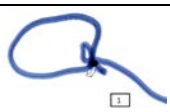
7		
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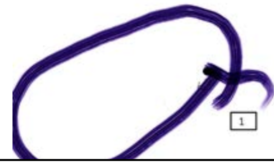
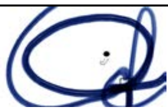
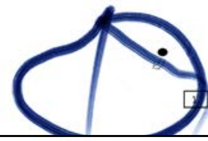
9		
10		
11		
12		

2) Overall Drawing Analysis on cross

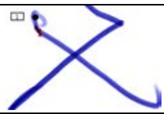
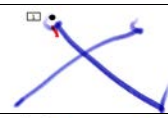
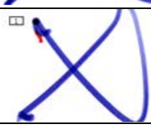
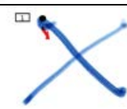
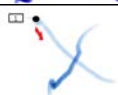
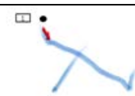
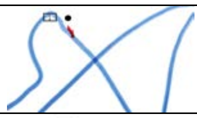
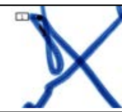
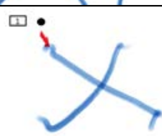
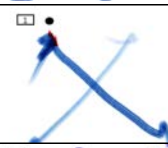
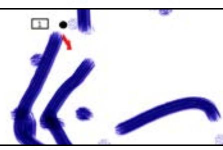
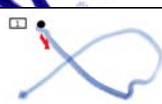
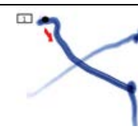
In Table 2, the pictures of participants drawing by their free-hand via Leap Motion were shown. Pictures in the same row were belong to the same person and were drawn in two different times. There are notable characteristics:

a) For the same person, the shape of two pictures is similar.

b) Only three cases out of twelve are shown complex lines for trying getting the cross.

c) Although the complex lines shown, these entire three participant did draw a line over the starting point.

Table 2 raw pictures of drawing cross

No	Test1	Test2
1		
2		
3		
4		
5		
6		
7		
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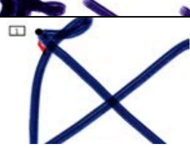
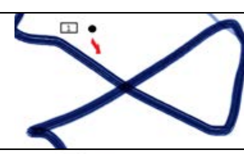
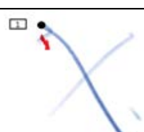
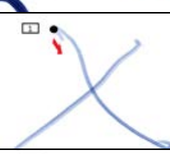
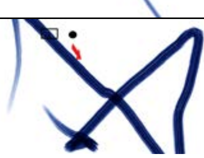
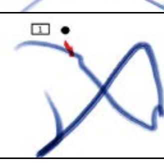
10		
11		
12		

3) *Overall Drawing Analysis on triangle*

In Table 1, the pictures of participants drawing by their free-hand via Leap Motion were shown. Pictures in the same row were belong to the same person and were drawn in two different times. There are notable characteristics:

a) *For the same person, the shape of two pictures is similar.*

b) *Only one case out of twelve is shown that well shape in the first drawing and out of control in the second drawing.*

c) *Only one case out of twelve is shown that well shape in the second drawing, but out of control in the first drawing.*

d) *There is one case out of twelve are shown that out of control in the first drawing and getting the shape in the second drawing.*

e) *There are two cases out of twelve are shown complex lines for trying getting the triangle shape.*

f) *Although the complex lines shown, these entire three participant did draw a line over the starting point.*

4) *Overall Drawing Analysis on square*

In Table 2, the pictures of participants drawing by their free-hand via Leap Motion were shown. Pictures in the same row were belong to the same person and were drawn in two different times. There are notable characteristics:

a) *For the same person, the shape of two pictures is similar.*

b) *Only one case out of twelve is shown that well shape in the first drawing and out of control in the second drawing.*

c) *Only one case out of twelve is shown complex lines for trying getting the square.*

d) *Although the complex lines shown, these entire three participant did draw a line over the starting point.*

C. *Locate the starting point*

In this session, the locating capability of the leap motion users would be evaluated according to how participants' performance on pointing at the starting point at their drawing procedure. The percentage of appropriate locating the starting point would be reported.

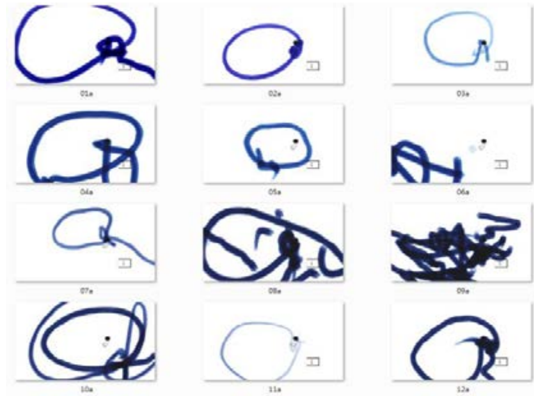


Fig. 12 Locations the starting point in the first circle drawing procedure

In Fig.12, there is 67% of students could draw from starting point at the first circle drawing procedure.

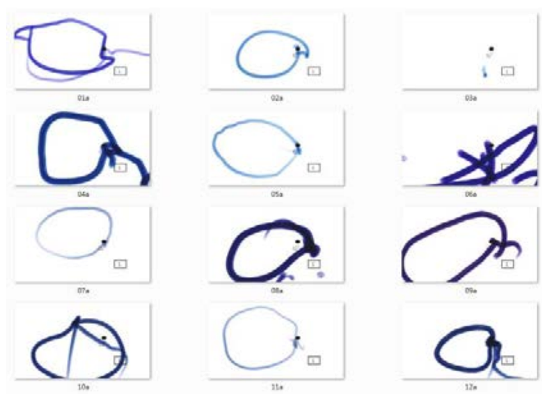


Fig. 13 Locations the starting point in the second circle drawing procedure

In Fig.13, there is 67% of participants could draw from the starting point at the second circle drawing procedure. The percentages of both the first and the second drawing are the same.

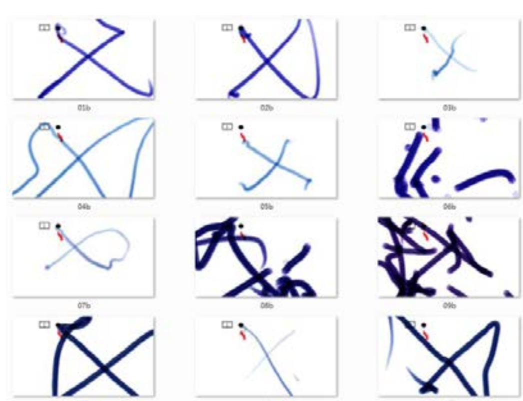


Fig. 14 Locations the starting point in the first cross drawing procedure

In Fig.14, there is 50% of students could draw from starting point at the first cross drawing procedure.

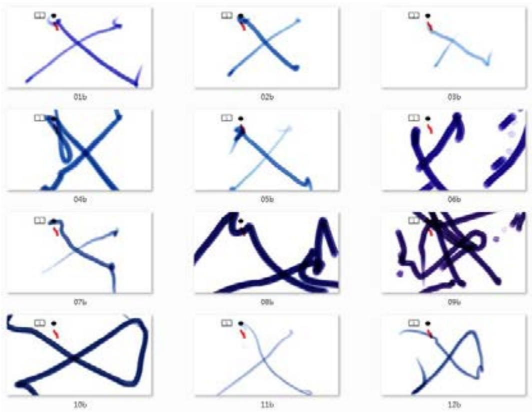


Fig. 15 Locations the starting point in the second cross drawing procedure

In Fig.15, there is 50% of participants could draw from the starting point at the second cross drawing procedure. The percentages of both the first and the second drawing are the same. .

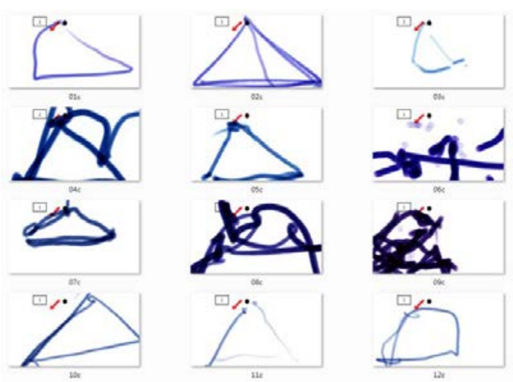


Fig. 16 Locations the starting point in the first trangle drawing procedure

In Fig.16, there is 42% of students could draw from starting point at the first triangle drawing procedure.

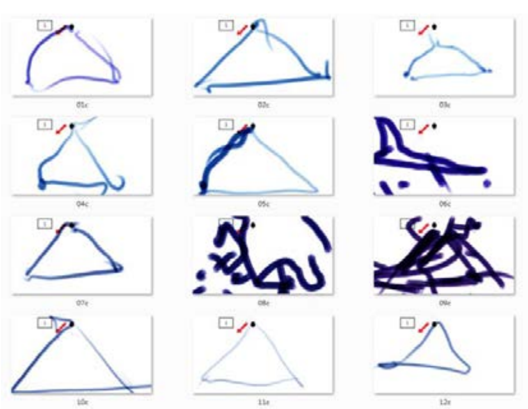


Fig. 17 Loations the starting point in the second trangle drawing procedure

In Fig 17, there is 67% of participants could draw from the starting point at the second triangle drawing procedure. The percentage of the first drawing is lower than the percentage of the second drawing. .

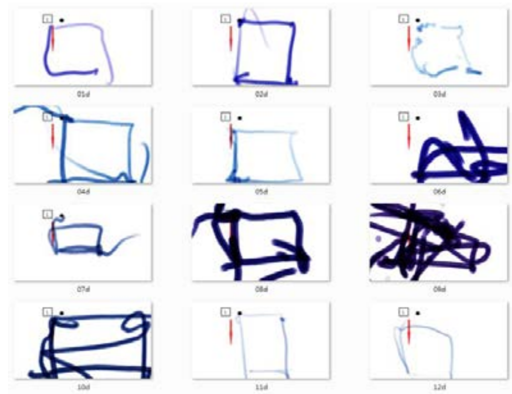


Fig. 18 Locations the starting point in the first square drawing procedure

In Fig.18, there is 33% of students could draw from starting point at the first square drawing procedure.

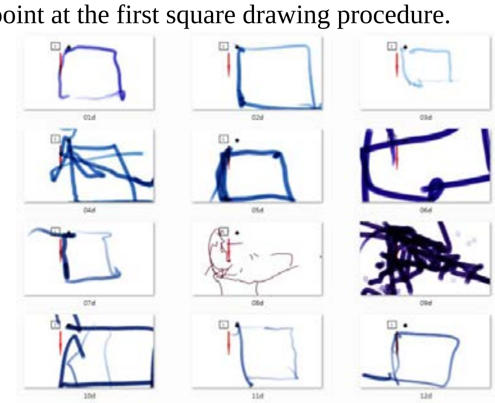


Fig. 19 Locations the starting point in the second triangle drawing procedure

In Fig.19, there is 42% of participants could draw from the starting point at the second triangle drawing procedure. The percentage of the first drawing is lower than the percentage of the second drawing.

D. Frequency Distributions

The operating time frequencies were reported in this session for exploring the distribution of gesture control device operating time intern of all participants. For cumulating into groups, a round function was applied on the raw data. Table 5 lists frequency, percent, and cumulative percent for the circle drawing time distribution.

Table 5 Circle Drawing Time Distribution Frequency Percent Valid

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	2	7.4	13.3	13.3
	2.00	1	3.7	6.7	20.0
	3.00	2	7.4	13.3	33.3
	4.00	2	7.4	13.3	46.7
	5.00	3	11.1	20.0	66.7
	6.00	2	7.4	13.3	80.0
	10.00	1	3.7	6.7	86.7
	15.00	1	3.7	6.7	93.3
	23.00	1	3.7	6.7	100.0
	Total	15	55.6	100.0	
Missing	System	12	44.4		
Total		27	100.0		

In Table 5. The time used to drawing circle is from 1 second to 23 second. The highest frequency required in drawing a circle is 5 second of three time as 20%.

Table 6 lists frequency, percent, and cumulative percent for the cross drawing time distribution. In Table 6. The time used to drawing circle is from 2 second to 13 second. The highest frequency required in drawing a circle is 4 second of three time as31.6%

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Table 6 Cross Drawing Time Distribution Frequency Percent Valid

		Frequen	Percent	Valid Percent	Cumulative Percent
Valid	2.00	2	7.4	10.5	10.5
	3.00	1	3.7	5.3	15.8
	4.00	6	22.2	31.6	47.4
	5.00	2	7.4	10.5	57.9
	6.00	4	14.8	21.1	78.9
	7.00	2	7.4	10.5	89.5
	10.00	1	3.7	5.3	94.7
	13.00	1	3.7	5.3	100.0
	Total	19	70.4	100.0	
Missing	System	8	29.6		
Total		27	100.0		

Table 7 Cross Drawing Time Distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.00	1	3.7	6.3	6.3
	3.00	1	3.7	6.3	12.5
	5.00	1	3.7	6.3	18.8
	6.00	1	3.7	6.3	25.0
	7.00	1	3.7	6.3	31.3
	8.00	2	11.1	12.5	43.8
	9.00	3	3.7	18.8	62.5
	10.00	1	7.4	6.3	68.8
	12.00	2	3.7	12.5	81.3
	13.00	1	3.7	6.3	87.5
	17.00	1	3.7	6.3	93.8
	19.00	1	3.7	6.3	100.0
	Total	16	59.3	100.0	
Missing	System	19	70.4	100.0	
Total		27	100.0		

Table 7 lists frequency, percent, and cumulative percent for the cross drawing time distribution. In Table 7. The time used to drawing cross is from 2 second to 19 second. The highest frequency required in drawing a circle is 9 second of three times as 18.8%.

Table 8 Square Drawing Time Distribution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4.00	1	3.7	5.6	5.6
	5.00	1	3.7	5.6	11.1
	6.00	2	7.4	11.1	22.2
	7.00	2	7.4	11.1	33.3
	9.00	3	11.1	16.7	50.0
	10.00	2	7.4	11.1	61.1
	11.00	1	3.7	5.6	66.7
	12.00	1	3.7	5.6	72.2
	13.00	1	3.7	5.6	77.8
	15.00	1	3.7	5.6	83.3
	16.00	1	3.7	5.6	88.9
	20.00	1	3.7	5.6	94.4
	30.00	1	3.7	5.6	100.0
	Total	18	66.7	100.0	
Missing	System	9	33.3	100.0	
Total		27	100.0		

Table 8 lists frequency, percent, and cumulative percent for the cross drawing time distribution. In Table 8. The time used to drawing square is from 4 second to 30 second. The highest frequency required in drawing a circle is 9 second of three times as 16.7%.

E. Descriptive Statistic of Operating

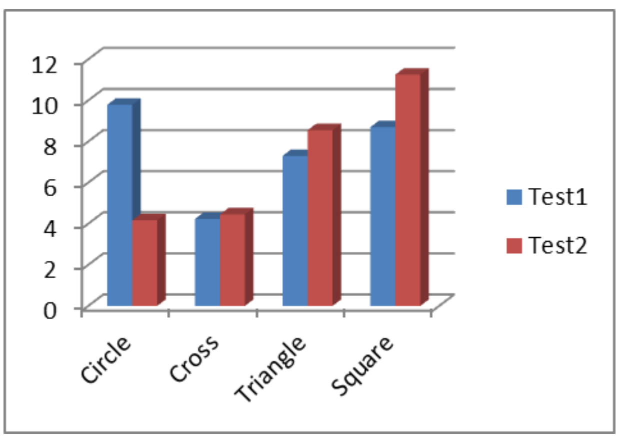
The mean time of each drawing procedure is reported in Table 9. For drawing a circle, the mean time is 9.78 seconds for the first drawing procedure and is 4.162 seconds for the second drawing procedure. The first cross drawing time is 4.224 seconds and the second drawing time is 4.45 seconds. The first triangle drawing time is 7.2967 seconds and the second drawing time is 8.549 seconds. The square drawing time is 8.69 seconds and the second square drawing time is 11.25 seconds.

Table 9 The Mean time of each drawing procedure Picture

Picture	Test1	Test2
Circle	9.78	4.162
Cross	4.224	4.45
Triangle	7.2967	8.549
Square	8.69	11.25

In Table 9, We could know that the Test2 may not be faster than Test1, so we could know that Leap motion isn't a technology could be adept in a short time . It needs to be taught and it also is a stable tool.

In Fig.13, the mean times of drawing circle, cross, triangle, and square are shown in the vertical bar. Only circle drawing time is getting shorter in the second drawing procedure.



IV. Conclusion

Leap motion is a new product in Gesture control. For exploring the feasibility, experiments were conducted. The purpose of this study was to verify the feasibility of using Gesture control on computer free-hand drawing in an educational environment for elementary students. A gesture control device, Leap Motion, was selected for this study. A field hands-on experiment environment was established for elementary students. The procedures of the hands-on experiment were

A. introducing the hardware and software used in the experiment,

B. video recording students' hand-movement of using Gesture control device and drawing results on the computer,

C. recoding the operating time for statistical analysis.

The experimental results and statistical evidence suggested the gesture control could be handled by elementary in free-hand drawing. Leap motion isn't a technology could be adept in a short time . It needs to be taught and it also is a stable tool .The average operating times and operating stability were also concluded.

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Yang-Ting Chen received her Bachelor (B.S.) in Industrial Technology Education (2010~2014) from National Kaohsiung Normal University. He is major in the technological systems of communication, construction, manufacturing and energy & power. With focus on emerging technology, his study would enhance emerging technology implementation. Mr. Chen was involved in the High-Scope Project, a project coping with emerging technology, with special center of attention of applying emerging technology for learning.

Miao-Kuei Ho received her Master (M.S.) in Industrial Technology Education (2003~2005) from National Kaohsiung Normal University. She is pursuing her Ph.D. in Industrial Technology Education from National Kaohsiung Normal University now. She has been teaching elementary school since 1990. As a senior teacher, she has had ten years field research experience with NSC projects. Her research interests include technology education, educational technology, and learning theory. She also has experts in technology process skills.

Hung-Jen Yang obtained a Master (M.S.) in Technology Education from University of North Dakota and a Ph.D. in Industrial Technology Education from Iowa State University. He is currently conducting research on knowledge transfer, and knowledge reuse via information technology. His research has appeared in a variety of journals including those published by the WSEAS.