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A Laser Point Interaction System Integrating Mouse Functions

Ching-Sheng Wang, Lun-Ping Hung, Sheng-Yu Peng, and Li-Chieh Cheng

***Abstract*—**The computer has become an essential tool in modern life, and the combined use of a computer with a projector is very common in teaching and presentations. However, as typical computer operating devices involve a mouse or keyboard, when making presentations, users often need to stay near the computer to execute functions such as changing pages, writing, and drawing, thus, making the operation time-consuming, and reducing interactions with the audience. This paper proposes a laser pointer interaction system able to simulate mouse functions in order that users need not remain near the computer, but can directly use laser pointer operations from at a distance. It can effectively reduce the users' time spent by the computer, allowing for greater interactions with the audience.

***Keywords*—**laser pointer, presentation, interaction, mouse function

I. INTRODUCTION

WITH the growing popularity of computer equipment, computer applications combined with a projector is common in business presentations and classroom instructions. However, as the operation of the computer is limited to the use of the mouse, users often have to remain near the computer, or go back and forth between the computer and the audience, thus reducing interactions with the audience or the full utilization of the computer by the users.

Although the interactive whiteboard available on the market can solve this problem, it is very expensive, costing a few hundred or even thousands of US dollars, which are unaffordable to average companies and schools. Therefore, this paper proposes a laser pointer that can simulate mouse movements, allowing the users to convenient operations and enhancing the functions of various computer software applications.

For the cost of less than one hundred US dollars for the proposed laser pointer and Internet camera, the same functions as an interactive whiteboard can be achieved. Since the laser light of the laser pointer is concentrated without scattering, users may operate the computer from a remote distance. When making presentations, users can underline or make drawings without returning to the computer to use the mouse, and thus have closer interactions with the audience.

After examining various operational methods of a simulated mouse, this paper presents a more accurate and efficient mode of operation. In addition to providing more complete, intuitive-based operating functions, the proposed system offers four kinds of operating modes to satisfy different needs. In each mode of operation, various kinds of functions can be accessed to allow users to select appropriate modes of operation, and thus, effectively improving operation accuracy and convenience.

The remainder of this paper is organized as follows: Section 2 introduces the related works and comparison. Section 3 presents the functions of proposed system. The detail of implementation is described in Section 4. Section 5 discusses the experiment and test results. Finally, the conclusion is given in section 6.

II. RELATED WORKS

Although there are similar studies on mouse simulation, there remains room for improvement in terms of system performance and mode of operation [1-12]. While designing the mode of operation, this study conducts a detailed comparison with other methods, and the operating modes of using the laser pointer can be divided into the following four types:

- *Direct method:* press the left button when laser spot is on, and release the left button when it disappears [1-2].
- *Gesture method:* in a given area, use the laser pointer to draw a "V" to represent a "click" and "VV" to represent a "double-click" [3-5].
- *Pattern method:* in a given area, use the laser pointer to draw simple patterns to judge actions; for example, a triangle represents a single click and a square represents a "double-click" [6-8].
- *Multi-button method:* the laser pointer provides several additional buttons, such as "Previous Page", "Next Page", as well as mouse left and right buttons [9-12].

The proposed system is a modified version of the direct method. This system uses an efficient imaging processing technology that can compute and render real-time effects. Its basic principle is to first move the mouse when the laser spot is on. Actions can only be triggered when the laser spot disappears, and it supports a variety of button menus to provide practical instruction functions.

Ching-Sheng Wang is with Department of Computer Science and Information Engineering, Aletheia University, Taiwan (e-mail: cswang@email.au.edu.tw).
Lun-Ping Hung is with Department of Information Management, National Taipei College of Nursing, Taiwan.
Sheng-Yu Peng is with Department of Computer Science and Information Engineering, Tamkang University, Taiwan.
Li-Chieh Cheng is with Department of Computer Science and Information Engineering, Aletheia University, Taiwan.

The comparisons of the above methods are shown in Table I. Although the direct method is easy to use, the main disadvantage is the accuracy of remote control. The disadvantage of the gesture and pattern methods is the higher rate of misjudgment, and thus, relatively low operational efficiency. The multi-button method requires specially designed hardware that may incur a high cost, and the button transmission distance may be limited by RF, Bluetooth, or infrared receiver. Compared with other methods, the "modified direct method" proposed in this paper will allow users to accurately target an object at a remote distance, and it can effectively implement accurate instructions.

TABLE I
COMPARISON OF OPERATING MODE

	Click /double-click /drag
Direct method	Advantage : quick response at short distance Disadvantage: lower accuracy when operating from a distance
Gesture method	Advantage : easy to use Disadvantage : higher rate of misjudgment of gestures
Pattern method	Advantage : easy to use Disadvantage: too big or small patterns may lead to misjudgments
Multi-button method	Advantage : direct use of button is more intuitive Disadvantage: requires specialty, high priced equipment
Modified direct method	Advantage: able to rapidly and accurately simulate mouse functions at a long distance Disadvantage :requires short term learning

III. SYSTEM FUNCTIONALITY

The laser pointer can be broadly divided into two types, according to functionality: 1) simple laser pointer with only a laser switch; 2) laser pointer with presentation function has two more buttons, [Previous Page] and [Next Page]. In addition, there are some presentation devices with laser features that provide more buttons to support functionality similar to a mouse; however, such devices are expensive. The idea of this system is to provide a more popular and less expensive laser pointer system that realizes remote control with more intuitive modes of operation, thus providing convenience for teaching and presentation. This system also provides different functions supporting single-button and three-button laser pointers.

When using this system, users can conveniently and remotely control the mouse, and move freely to facilitate interaction with the audience when making presentations. According to the functions of the laser pointer (single-button or three-button) and user requirements (mouse mode or presentation mode), this system provides four modes for users: single-button mouse mode (M-mode), single-button presentation mode (P-mode), three-button mouse mode, and three-button presentation mode. The system functionality is shown in Table II.

The single-button mode is designed for laser pointers with only the laser irradiation function, as most users may only have the simple function laser pointer. The mode can be further divided into the mouse mode and the presentation mode. The mouse mode simulates mouse functionality, while presentation mode is specifically for making presentations. There are some different functions in each mode. The single-button mouse mode has functions, such as "move, click, double-click, drag and drop". When switching functions, the user may move the spot light to the menu to switch modes.

TABLE II
SYSTEM FUNCTIONALITY

Mode of operation / Type of Laser pointer	Mouse mode (M-mode)	Presentation mode (P-mode)
Single-button laser pointer	Move, click, double-click, drag and drop	Move, click, write
Three-button laser pointer	Move, click, double-click, drag and drop	Move, click, write, changing pages

The function of "move," moves the mouse without a click. The function of "click" is the same as the click of the mouse left button. The remote operation of the "click" function may cause some inconveniences as it is not easy for users to select an object at a distance when the laser pointer is turned on. It is very likely to click an undesired object and result in unwanted disruptions. Therefore, this system proposes a solution: when the laser spot light appears, users may move the mouse without a click; when the mouse is moved to the desired object, then users may switch on the laser pointer to allow the system to execute the single click.

The principle of double-click is similar to that of single click. To execute "drag and drop", users can move the laser spot light to the object to be dragged, release, and then press the button to drag the object the desired place. In the single-button mouse mode, users may timely switch the functions of click, drag and drop, or draft freely in Microsoft Paint. This mode is also fully supported in the three-button mode.

The single-button presentation mode has functions, such as "move, click, and write". When making a presentation, users may make more detailed explanations on a given page of the projected document. At this time, only the function of "move" is required. Execution of the function of "click" in projection will execute the order of "next page". Before the execution of "write", users must execute the click function to select marker or light pen provided by PowerPoint, and then switch to the function of "write" to use a function similar to the drag of the single-button mouse mode for writing in a projection.

The three-button mode is specifically designed for laser pointers with the feature of changing pages. The laser pointer with the feature of changing pages has two buttons, [Previous Page] and [Next Page], in addition to the regular functions of the laser pointer. This system uses these two buttons to simulate the left and right buttons of the mouse. The button of [Previous Page] simulates the right button of the mouse, while [Next

Page] simulates the left button of the mouse. For the three-button laser pointer, this system also provides two modes of operation: the three-button mouse mode and the three-button presentation mode.

The three-button mouse mode has functions, such as “move, click, double-click, drag and drop”, while functions such as “click, double-click, and drag” of the single-button mouse mode are still available. However, users may switch to the “move” function to move the indicator, and then press the up/down page buttons of the laser pointer to execute the left and right buttons of the mouse. The three-button presentation mode has functions, such as “move, click, write, and changing pages”. The functions of “move, click, and drag” are the same as the above-mentioned, while the function of changing pages effectively makes use of the [Previous Page] and [Next Page] of the three-button presentation laser pointer. The function of changing pages will resume the right button simulation of [Previous Page] to the previous page. [Next Page] does not need to be restored, as in PowerPoint, holding down left button can change the projected document to the next page. As the three-button mode can simulate the left and right buttons of mouse, the simulation is more complete and more intuitive.

IV. STSYEM IMPLEMENTATION

This system is developed based on Direct Show SDK in programming language C++. The system processing procedure is shown in Figure 1. Based on image processing technology and theory, this system analyzes the video image, captures, and corrects the coordinates of the laser spot light. Based on the analysis of the spot light status, the command type and output command can be determined to further simulate the mouse command.

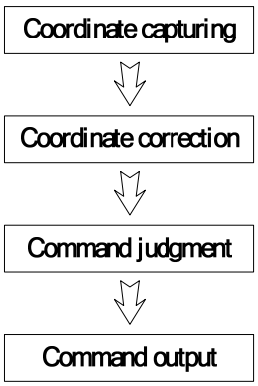

Fig. 1 Flowchart of the implementation

A. Coordinate Capturing

As shown in the photos of a laser pointer captured by a camera, whether it is a red or green light, the central laser light spot is very bright, therefore, this system adopts the method of direct processing of brightness, using this characteristic. The principle conducts gray-scale processing, after capturing pictures from a video, and then conducts the binarization process after obtaining the threshold values. In principle, the image color is composed of Red, Green, and Blue, and the conversion of color image to grayscale may be quickly completed by the following equation:

$$Gray = 0.299\ R + 0.587\ G + 0.114\ B$$

After the gray-scale equation conversion, the image color ranges will be between 0 (black) ~ 255 (white). Then, the binarization equation conversion is performed. The ambient light will automatically be determined by the system, and an appropriate threshold value is set. The grayscale is larger than the threshold value as white (255), and those less than the threshold values as black (0). The binarization equation is as follows:

$$g(x,y) = \begin{cases} 0, & if\ \ g(x,y) < Threshold \\ 255, & if\ \ g(x,y) > Threshold \end{cases}$$

After binarization processing, black or white images can be obtained. Then, the focus of the white spot cluster is found to obtain the coordinates of the spot light.

B. Coordinate correction

The use of image processing technology can identify the location of a laser pointer spot light; however, the image captured by the camera may not necessarily cover the entire projection screen. In order to correctly match the laser spot light to the screen, this study uses 3D technology to convert the captured projection screen into a matrix of coordinates. By using the advantage of the matrix characteristics, multiplied by the rotating matrix and scaling matrix, the original 320*240 resolution can be converted into the common 1024*768 size for further analysis. The following is the correction equation to convert rectangular coordinates into quadrilateral coordinates [13]:

$$\begin{pmatrix} uq \\ vq \\ q \end{pmatrix} = \begin{pmatrix} e-fh & ch-b & bf-ce \\ fg-d & a-cg & cd-af \\ dh-eg & bg-ah & ae-bd \end{pmatrix} \begin{pmatrix} x \\ y \\ 1 \end{pmatrix}$$

From the above equation:

$$(u,v) = \left(\frac{(e-fh)x + (ch-b)y + bf - ce}{(dh-eg)x + (bg-ah)y + ae - bd}, \frac{(fg-d)x + (a-cg)y + cd - af}{(dh-eg)x + (bg-ah)y + ae - bd} \right)$$

where x, y are the original coordinates, u, v are the coordinates after normalization at the first stage. While 8 variables, including a,b,c,…h can be determined by the coordinates of the four vertexes coordinates x0, x1, x2, x3, y0, y1, y2, y3, then calculate the a, b, c, …, h as:

$$a = x_1 - x_0 + gx_1$$
$$b = x_3 - x_0 + hx_3$$
$$c = x_0$$
$$d = y_1 - y_0 + gy_1$$
$$e = y_3 - y_0 + hy_3$$
$$f = y_0$$

$$g = \begin{vmatrix} \sum x & \Delta x_2 \\ \sum y & \Delta y_2 \end{vmatrix} \Big/ \begin{vmatrix} \Delta x_1 & \Delta x_2 \\ \Delta y_1 & \Delta y_2 \end{vmatrix}$$

$$h = \begin{vmatrix} \Delta x_1 & \sum x \\ \Delta y_1 & \sum y \end{vmatrix} \Big/ \begin{vmatrix} \Delta x_1 & \Delta x_2 \\ \Delta y_1 & \Delta y_2 \end{vmatrix}$$

$$\Delta x_1 = x_1 - x_2 \quad \Delta x_2 = x_3 - x_2$$
$$\Delta y_1 = y_1 - y_2 \quad \Delta y_2 = y_3 - y_2$$
$$\sum x = x_0 - x_1 + x_2 - x_3$$
$$\sum y = y_0 - y_1 + y_2 - y_3$$

Finally, input *u, v* into the following equation:

$$\begin{pmatrix} XW \\ YW \\ W \end{pmatrix} = \begin{pmatrix} 1024 & 0 & 0 \\ -1024 & -768 & -2 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} u \\ v \\ 1 \end{pmatrix}$$

From the above equation:

$$(X, Y) = (1024\,u, -1024\,u - 768\,v - 2)$$

Then the ultimate coordinates *X, Y* can be obtained. Figure 2 shows the correction conversion.

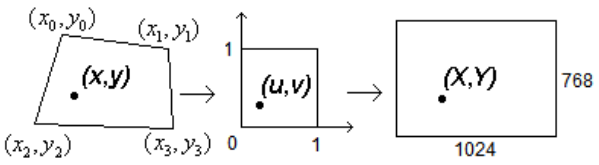

Fig. 2: Illustration of coordinate correction

C. Command judgment

The commands of mouse include "move, click, double-click, and drag". To switch functions, users only need to move the mouse to items of the function list without clicking, because the most basic function of the laser pointer is to move. If the "move" function is switched, no click is allowed, therefore, the command function switching of this system is achieved by "move" rather than "click".

The "move" function moves along with the laser pointer spot light when it is switched on. When laser pointer light spot is off, the mouse does not move. For all the functions of this system, the mouse can be moved when the laser pointer spot light is on. The function of single click moves to the object to be single clicked, when the light spot is on, and executes the single click function when the light spot is off. The principle of double-click is the same: execute double-click when the light spot is off.

The command of drag is divided into two stages: 1) select the object; and 2) drag the object. When the light spot is on, the light spot is moved to the object to be dragged, and the object is single clicked, when the light spot is off. When the light spot is on once again, it is the time to drag the object to the desired location, and then the laser pointer button is released to complete dragging. The mouse_event time sequence analysis is shown in Figure 3.

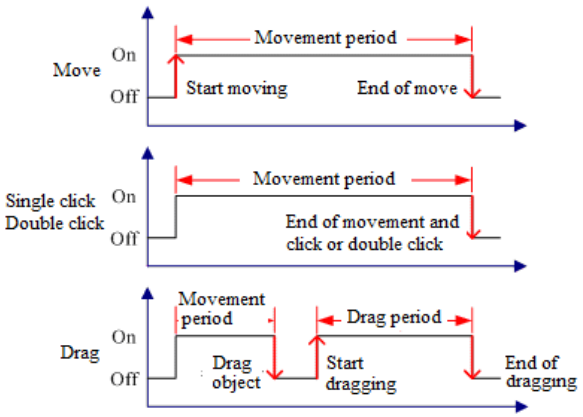

Fig. 3: Illustration of mouse_event analysis

D. Command output

After coordinate correction, the original projection images can be converted into 1024*768 coordinates. This system uses the mouse_event function of Win32 to simulate the mouse into the correct coordinates. In this way, in vision, the laser pointer spot light and mouse are at the same position on the projection screen. Mouse_event function is simulated to make commands such as "move, single-click, double-click, and drag". Thus, the mouse coordinates and commands can be fully simulated.

V. EXPERIMENTS AND RESULTS

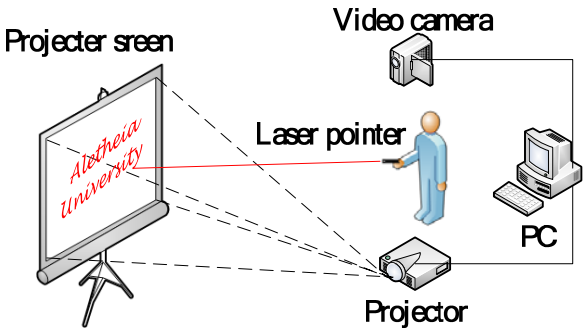

Fig. 4: Illustration of proposed system

The operating environment of this system is Window XP. Users should first select the laser pointer type (single-button or three-button laser pointer). Figure 4 shows the configuration of this system. The video camera may be located anyplace, as long as the entire projector screen can be captured. In the beginning

of operation, some adjustments of video camera options should be made. Users should remove the options for white balance and automatic gain control, as such options may automatically adjust the white balance and exposure of the video camera, resulting in misjudgments. Then, brightness and exposure values should be adjusted to allow laser pointer light spots to generate a larger white point, in order to achieve better system stability.

The following is the corner positioning. The method proposed by this study can allow the users to select the boxes at the four corners by mouse, move the box to match the scope of the projector screen, and carry out coordinate correction. Thus, the laser pointer light spot and mouse cursor can be correctly matched.

After corner positioning, the mode of operation can be selected (various functions of the selection menu are detailed in Section 2) to being the operations. During operation, the function menu is displayed at the top and is set as above all windows in order to avoid being blocked by any other window when the users switch the functions (as shown in Figure 5). When switching functions, the users can move the mouse to a feature icon to smoothly switch functions. Then, the users can use the laser pointer like mouse to operate software (as shown in Figure 6).

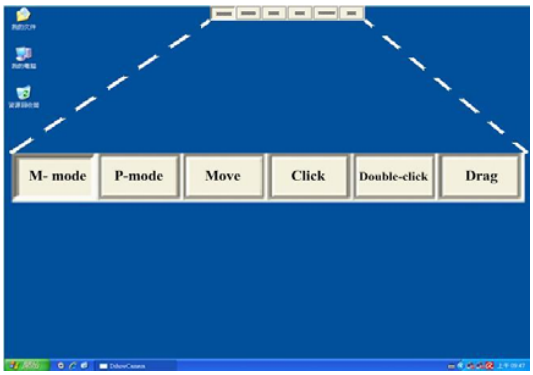

Fig. 5: Illustration of system functions

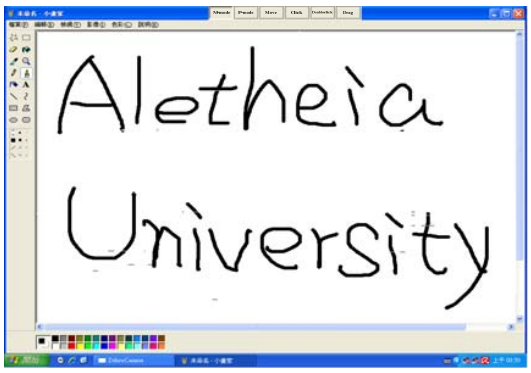

Fig. 6: Illustration of writing in Microsoft Paint

VI. Conclusions

This paper proposes a laser pointer interaction system that can simulate the functionality of a mouse. The system allows users to control the laser pointer at a distance to effectively and efficiently operate the computer, thus reducing the time wasted from remaining near the computer and enhancing interactions with the audience. Compared with other methods, this system has four modes of operations that enable the users to operate the computer more conveniently and accurately. With its high practical utility, this system can improve traditional presentation and teaching, while enhancing the performance of teaching and learning. Future studies will attempt to integrate this system with the virtual reality or applications, such as navigation, computer games, to allow users to have more intuitive and greater efficiency in interactions with the computer.

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Dr. Ching-Sheng Wang is an associate professor in the Department of Computer Science and Information Engineering at Aletheia University, Taiwan. His main research interests include image processing, virtual reality, 3D human computer interface, content-based information retrieval and RFID positioning. He received his Ph. D. degree in the Department of Computer Science and Information Engineering from Tamkang University, Taiwan in 2001. Dr. Ching-Sheng Wang has published over 50 papers in international journals and conferences, and earned several research awards and grants, as well as participated in many international academic activities.

Lun-Ping Hung is an associate professor in the Department of Information Management Department at National Taipei College of Nursing, Taiwan. He earned his Ph.D. at Tamkang University in Taiwan. His research interests include quantitative analysis of distance learning courses, the discovery of customer behavior analysis in mobile commerce and the recommendation technologies for customer relationship management.

Mr. Sheng-Yu Peng, was an undergraduate student in the Department of Computer Science and Information Engineering at Aletheia University, Taiwan. Now, he is a master student in the Department of Computer Science and Information Engineering at Tamkang University, Taiwan. His research topic is image processing.

Mr. Li-Chieh Cheng is an undergraduate student in the Department of Computer Science and Information Engineering at Aletheia University, Taiwan. His research topic is image processing and RFID positioning.