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A Wireless Presenter with Computer Mouse Functions

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Abstract

Commercially available wireless presenters have limited functions for presentation with beam projector such as "go to next slide" and "back to previous slide" in an application such as MS PowerPoint. Thus, there is inconvenience associated with carrying out other functions, e.g., execution or termination of an application and maximization or minimization of a window, during the presentation. The objective of this study is to implement a wireless laser pointer mouse that has the same functions as a computer mouse. In order to determine the position of the laser spot in the projector display, image processing that detects the laser spot in the camera image is required. In addition, transformation of the spot position into computer display coordinates is needed to execute computer controls.

Key Words: Vision sensor, Presentation, Laser pointer, Beam projector, Wireless presenter

1. Introduction

Beam projectors are commonly used in presentations to deliver visual information to an audience. In order to point out a specific area in the projected image, a computer mouse or a laser pointer is employed. As a simple pointing device, the laser pointer produces a red or green laser spot that is distinguishable from a displayed image on the projector screen. In addition to this pointing function, a computer mouse has computer control functions, e.g., execution or termination of an application and maximization or minimization of a window. A commercially available device known as a wireless presenter offers the simple pointing function of a laser pointer and a few computer control functions. The wireless presenter transmits button signals to a main computer through a wireless channel. However, this wireless presenter has limited functions for computer control in a specific application, e.g., "go to next/previous slide" in MS PowerPoint. Thus, for the wireless presenter, it is impossible to carry out most of the computer control functions that can be performed by the computer mouse [6].

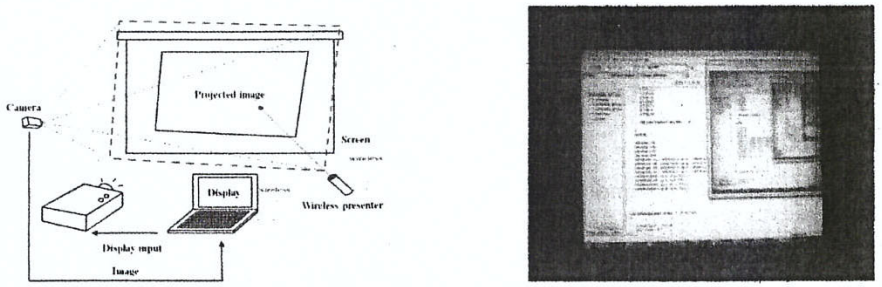
In order to address this problem, this study aims to develop a laser pointer mouse by combining the laser pointer and the computer mouse. To implement the computer control functions, it is necessary to detect the position of a pointer on the computer display. In the case of the computer mouse, it is possible to detect the pointer position by mouse wheel rotation or optical reflection on a surface. In order to carry out computer control functions

based on a laser spot, it is necessary to (1) detect the laser spot on the screen through camera image processing, (2) transform the position of the laser spot in the camera image coordinates into the position in computer display coordinates, and (3) generate and transmit the button signals of a computer mouse through a wireless channel to a main computer.

2. Laser Pointer Mouse

2.1. Presentation environment

The laser pointer mouse system proposed in this paper is shown in Fig. 1 (a). In addition to ordinary beam projector, a camera is installed on the computer and arranged so that an image of the full projected screen can be acquired (Fig. 1 (b)). The acquired image is sent to the computer, and the laser pointer spot can be detected in the image. Since most of the computer control functions can be carried out by clicking buttons, the laser pointer mouse should have buttons and a wireless module that can transmit the button signals to the main computer.



(a) Presentation environment (b) Computer display region in the camera image

Fig. 1. Laser pointer mouse system

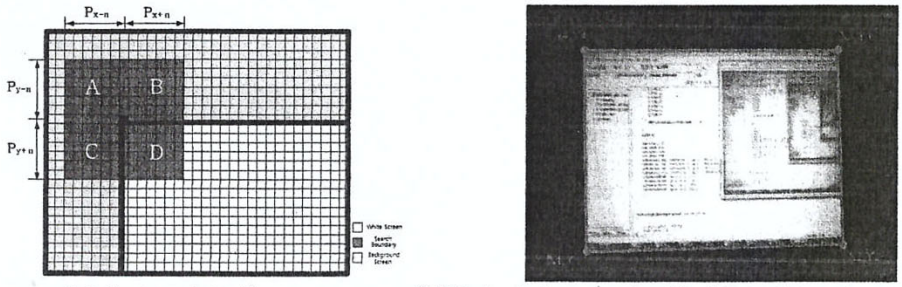
2.2. Extraction of computer display region from the camera image

The acquired camera image may contain the background screen and other surroundings in addition to the projected computer display region, as shown in Fig. 1 (b). It is necessary to extract the computer display region from the camera image to detect the laser spot and transform its location into computer display coordinates.

By detecting the four corners of the computer display region, it is possible to extract this region from the camera image. The projected computer display region in the camera image is brighter than the background region in the image. Thus, as shown in Fig. 2, it is easy to detect the four corners of the region from the sum of pixel intensities in 5×5 sub-areas A, B, C, and D at a certain point (x, y) in the image, as follows [1]:

If $Total(D) > Total(A), Total(B), Total(C)$, then (x, y) is the left-top corner;
If $Total(C) > Total(A), Total(B), Total(D)$, then (x, y) is the right-top corner;
If $Total(B) > Total(A), Total(C), Total(D)$, then (x, y) is the left-bottom corner;

If $Total(A) > Total(B), Total(C), Total(D)$, then (x, y) is the right-bottom corner, where $Total(\cdot)$ denotes the sum of pixel intensities in a sub-area. Fig. 2 (a) illustrates the corner detection algorithm, and Fig. 2 (b) shows the detected four corners of the computer display region in the camera image. In Fig. 2 (b), the coordinate values (x_i, y_i), $i = 1, \cdots, 4$ of the corners are represented in the camera image coordinates.



(a) Corner detection (b) Detected computer display region extracted

Fig. 2. Corner detection for the computer display region

2.3. Detection and transformation of laser spot into computer display coordinates

In order to implement the computer control functions of the laser pointer mouse, the laser spot should be detected first in the camera image. Since a distinguishable laser light source is used in a presentation, it is easy to detect the laser spot location in the camera image by searching for a pixel with maximum intensity [2]. If the contrast level of the camera image is set too high, it might be impossible to detect the laser spot pixel owing to intensity saturation. As preprocessing for the camera image, an automatic algorithm for adjusting the contrast level is developed in this paper.

Once the laser spot has been detected, its position in the camera image coordinates should be transformed into the computer display coordinates in order to synchronize the mouse cursor to the laser spot and to make the computer controls accessible to the laser pointer mouse. It should be noted that the extracted computer display region in the camera image may contain tilt and deformation in accordance with the position and orientation of the camera setup. If the dimensions of the computer display (e.g., 1024×768) are known, coordinate transformation is possible based on the relationship between the original dimensions and the extracted dimensions of the computer display region (Fig. 2 (b)).

The well-known warping transformation defines the relationship between the original coordinate value P' of the computer display and the detected coordinate value P of the corresponding region in the camera image, as follows [3][5]:

$$P' = M \cdot P \tag{1}$$

Once the transformation matrix M is determined, it can be used to transform the coordinate value of the laser spot detected in the camera image to the value in the original computer display coordinates. The computer display and the camera image are both two-dimensional, so the transformation between them can be written as follows:

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ 1 \end{bmatrix} \tag{2}$$

Here, $[x'\ y'\ 1]'$ and $[x\ y\ 1]'$ represent the homogeneous coordinates of the computer display and the camera image, respectively. Expanding (2) with respect to x' and y' gives the following set of equations:

$$\begin{aligned} x' &= ax + by + c - gxx' - hx'y \\ y' &= dx + ey + f - gxy' - hyy' \end{aligned} \tag{3}$$

From the known resolution of the computer display, the coordinate values of the four corners of the computer display are calculated, and these correspond to the four detected corners in the camera image (see Fig. 2 (b)). For example, if the resolution of the computer display is 1024×768, (x_3', y_3') in the computer display coordinates corresponding to right-top corner (x_3, y_3) in Fig. 2 (b) is $(1024, 768)$. Rewriting (3) with respect to unknown variables a through h using these four coordinate-transformation pairs yields the following:

$$\begin{bmatrix} x_1' \\ y_1' \\ x_2' \\ y_2' \\ x_3' \\ y_3' \\ x_4' \\ y_4' \end{bmatrix} = \begin{bmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1x_1' & -x_1'y_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -x_1y_1' & -y_1y_1' \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2x_2' & -x_2'y_2 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -x_2y_2' & -y_2y_2' \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3x_3' & -x_3'y_3 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -x_3y_3' & -y_3y_3' \\ x_4 & y_4 & 1 & 0 & 0 & 0 & -x_4x_4' & -x_4'y_4 \\ 0 & 0 & 0 & x_4 & y_4 & 1 & -x_4y_4' & -y_4y_4' \end{bmatrix} \cdot \begin{bmatrix} a \\ b \\ c \\ d \\ e \\ f \\ g \\ h \end{bmatrix} \tag{4}$$

From this matrix equation, unknown variables a through h can be solved and thus the transformation matrix in (2) can be determined. Fig. 3 presents an image of the computer display region obtained by applying (2) to Fig. 2 (b). Since the image has been transformed according to the computer display resolution, by applying the same transformation to the laser spot position detected in the camera image, it is possible to determine the corresponding coordinate value in the original computer display coordinate system. Using this coordinate

value, it is possible to synchronize the cursor of the computer mouse to the laser spot, and the computer controls available on the computer display can be executed.

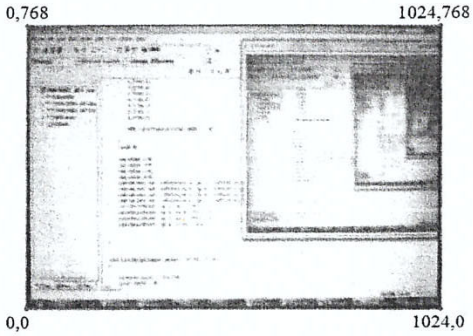
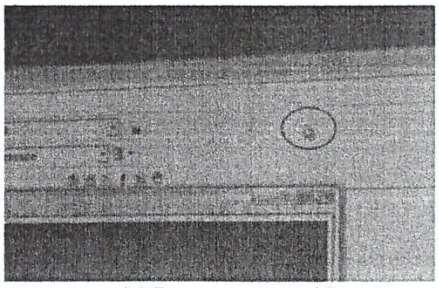


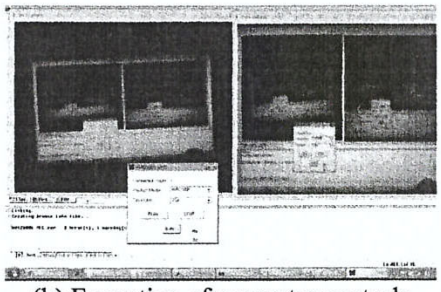
Fig. 3. Image transformed into the computer display coordinates

3. Results of Experiments

In this study, a USB camera with 1024×768 resolution and 26 frames-per-second acquisition rate is used. The laser pointer mouse needs a set of buttons to execute computer controls and a wireless module to transfer the button signals. The buttons should correspond to the left and right buttons of the computer mouse. Of course, the main computer must have a wireless module to receive the signal from the laser pointer mouse. In this paper, a commercially available wireless presenter is employed for the laser spot generation and the wireless module [4]. As described above, the commercial wireless presenter has two buttons for simple functions (e.g., flipping pages) in an application such as MS PowerPoint. By simply installing the image processing program developed in this study, it is possible to use the commercial wireless presenter as a laser pointer mouse.



(a) Laser spot tracking



(b) Execution of computer controls

Fig. 4. Experimental results

Fig. 4 presents the experimental results. In Fig. 4 (a), it can be seen that the mouse cursor and the laser spot coincide with each other. This demonstrates the successful operation of the algorithms for extracting the computer display region in the camera image, detecting the laser

spot in the camera image, transforming the laser spot position into the computer display coordinate system, and shifting the computer mouse cursor to the laser spot location. Once the mouse cursor tracks the laser spot movement, the computer controls or the icons on which the cursor is located can be executed by the laser pointer mouse. Fig. 4 (b) shows the controls being executed by the laser pointer mouse after the computer display region in the camera image is transformed.

4. Conclusion

In this study, a laser pointer mouse is developed; this device combines a simple laser pointer and a computer mouse for executing functions on the computer display. Image processing is used to extract the computer display projected on the screen, detect the laser spot in the camera image, and transform the spot location into the computer display coordinates, thus making the mouse cursor coincide with the laser spot. The experimental results indicate that it is difficult to synchronize the mouse cursor with the rapidly moving laser spot owing to the relatively slow (~30 frames per second) image acquisition rate of the camera. However, since it is normal for a user to stabilize the laser spot movement near the desired computer control area, there should not be any problem in accessing the controls with the laser pointer mouse.

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