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A Large Panel Two-CCD Camera Coordinate System with an Alternate-Eight-Matrix Look-Up Table Algorithm

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Abstract

In this study, a novel positioning model of a double-CCD cameras calibration system, with an Alternate-Eight-Matrix (AEM) Look-Up-Table (LUT), was proposed. Two CCD cameras were fixed on both sides of a large scale screen to redeem Field Of View (FOV) problems. The first to the fourth AEMLUT were used to compute the corresponding positions of intermediate blocks on the screen captured by the right side camera. In these AEMLUT for the right side camera, the coordinate mapping data of the target in a specific space were stored in two matrixes, while the gray level threshold values of different position were stored in the others. Similarly, the fifth to the eighth AEMLUT were used to compute the corresponding positions of intermediate blocks on the screen captured by the left side camera. Experimental results showed that the problems of dead angles and non-uniform light fields were solved. In addition, rapid and precision positioning results can be obtained by the proposed method.

Keywords: calibration system , Alternate-Eight-Matrix, Look-Up-Table, Field Of View, gray level threshold.

1. Introduction

Mouse, keyboard, handlebar, touch panel, and joystick are conventionally used as human-machine interfaces (HCIs). In recent years, interfaces based on video tracking technology have been developed for noncontact interaction [1-3]. Video cameras are used for target tracking and video communication. Detection of a user’s hand positions and orientation are also fundamental in the development of vision-driven user interfaces [2]. Human–computer interaction (HCI) research into video games is different from other forms of software. Unlike most software, video games are not made to support external, user-defined tasks, but instead define their own activities for players to engage in [3-5].

Two-camera spatial positioning employs a Lookup Table (LUT), which builds a connection between the index value and output value in image processing [2]. Each camera has a group of LUT-x and LUT-y connections, demonstrating the connections between the feature point position captured and the actual position, which has the advantage of rapid computation and real-time response to positioning requests. C.S. Lin et al. developed a special human-machine interface by combining two CCD cameras and a large computer screen, and linked rehabilitation equipment to the interactive game [6].

In this study, two CCD cameras were fixed on both sides of a large scale screen for video gaming and human–computer interactions. The cursor position changes as the yellow ball moves. An Alternate-Eight-Matrix (AEM) Look-Up-Table (LUT) was proposed. The first to the fourth AEMLUT were used to compute the corresponding position of the intermediate block on the screen captured by the right side camera. In the AEMLUT of the right side camera, the coordinate mapping data for the target in a specific space were stored in two matrixes, while the gray level threshold values of different positions were stored in the others. Similarly, the fifth to the eighth AEMLUT were used to compute the corresponding positions of the intermediate blocks on the screen captured by the left side camera.

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2. The design of the 8-LUT system with two CCD cameras

2.1. Generation of 8-LUT table database

The coordinate position of an object in a fixed range is detected by two cameras, where the two cameras are placed on both sides of the screen, and shoot the object from different angles in order to obtain the coordinate position of the object in space, according to the Alternate-Eight-Matrix Look-Up Table. Area <a>, which is detected by the right camera, is the range of application of the first and second matrix look-up tables, while area <b>, which is detected by the left camera, is the range of application of the third and fourth matrix look-up tables. The space positioning and threshold matrix with two cameras establishes a connection relationship between the index values and output values using the AEMLUT. The output value corresponding to the memory in the program can be obtained through the look up table method. The processing speed of this method is usually much faster than complicated mathematical expressions.

If C_1 is the pixel group formed by the yellow ball target, and the gray scale value of the color component of the pixels of the target in this color model is *I* to *L*, allowing the yellow ball target to be successfully cut out. Therefore, when the target is in the actual position (*x,y*), the optimal threshold of r color component of the image in this color model is k. In the same way, when a g color component is used for generating the threshold, if the C_1 gray scale value range is within the pixel group of [*l+1, l +2,...L*], then the number of C_1 is *n*, therefore, *l* is the optimal threshold of the g color component of the image in this color model, providing the target is in the actual position (*x,y*).

All the pixels of a target, separated by r and g color components in this color model, are gathered, and it is known that, by using the center of gravity method the center of the yellow ball image in position (*x,y*) is (*x',y'*). The first LUT A_1 stores coordinate x corresponding to the actual position in the array element (*x',y'*). The second LUT A_2 stores coordinate y corresponding to the actual position in the array element (*x',y'*)

$$\begin{cases} A_1(x', y') = x \\ A_2(x', y') = y \end{cases} \quad (1)$$

Here the *k* value can be filled in the array element (*x',y'*) in the third LUT A_3. Here the *l* value can be filled in the array element (*x',y'*) in the fourth LUT A_4.

$$\begin{cases} A_3(x', y') \to k \\ A_4(x', y') \to l \end{cases} \quad (2)$$

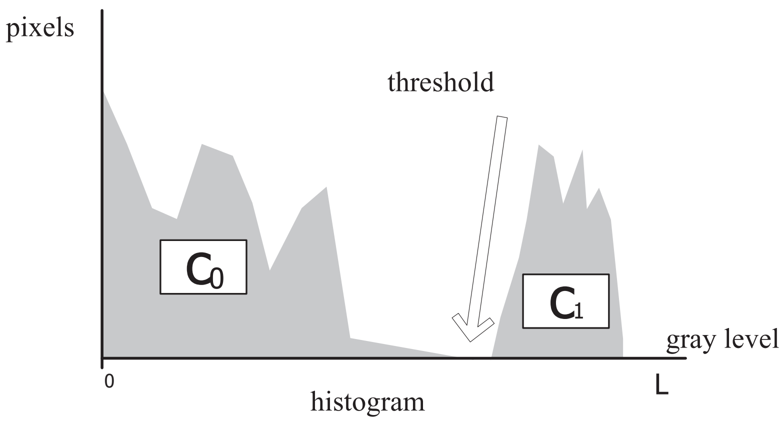


Fig. 1. All the pixels of the entire image are divided into two parts: background C_0 and yellow ball target C_1.

When camera <b> is considered, it can be known by using the same method that the optimal threshold of the r color component of the image in this color model is p, and the optimal threshold of the g color component in this color model is q, and are obtained by using the center of gravity method, when the center of the yellow ball image in position (*x,y*) is (*x'',y''*). The fifth LUT A_5 stores coordinate y corresponding to the actual position in the array element (*x'',y''*). The sixth LUT A_6 stores coordinate y corresponding to the actual position in the array element (*x'',y''*).

$$\begin{cases} A_5(x'', y'') = x \\ A_6(x'', y'') = y \end{cases} \quad (3)$$

Here the *p* value can be filled in the array element (*x'',y''*) in the seventh LUT. And the *q* value can be filled in the array element (*x'',y''*) in the eighth LUT.

$$\begin{cases} A_7(x'', y'') \to p \\ A_8(x'', y'') \to q \end{cases} \quad (4)$$

When the calibration points in the LUT Table are far apart, the system will fill in the values of two calibration points in LUT using the interpolation method. When the calibration points are too close, the system will set the LUT values to correspond to the two calibration points as equivalent to the last calibration point.

The index value <b> should be filled in by the LUT if the unfilled area is in the region within the detection range of Camera <b>, and the index value 'o' should be filled in if the unfilled area is 'outside' the detection range of the two cameras in order to judge whether to switch the cameras or whether the detected object breaks the boundaries.

In A_1 and A_2, the index value <b> is used to represent that the region should be within the detection range of Camera <b>, and index value 'o' is used to represent that the region should be 'outside' the detection range of the two cameras. Then, the camera <b> makes all the points in the work area into a LUT table through the same procedure, and the corresponding numeric database inside the eight-matrix is automatically completed using this correction program. The corresponding numeric database inside the 8-LUT of A_1, A_2, A_3, A_4, A_5, A_6, A_7, and A_8 is automatically generated.

2.2. Using 8-LUT for coordinate conversion and binarization

When searching for the target object (yellow ball), this study first adjusted the proper binarization threshold value T for the image input, while simultaneously calculating the coordinates of the center of the target as the initial value. The initial center point of the target (x_0,y_0) was obtained by calculating the centroid of the bright pixel from the simple bi-level image threshold t_0.

$$x_0 = \sum \frac{x_i}{m}, \; y_0 = \sum \frac{y_i}{m} \tag{5}$$

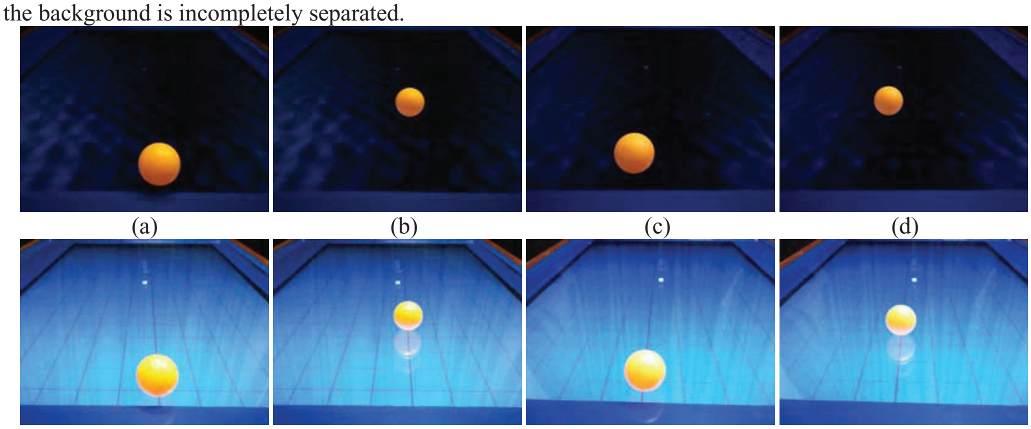
where, x_i and y_i: are the x-axis and y-axis coordinates of a bright pixel in an entire image, and m is the number of bright pixels.

This system first uses single threshold binarization, thus, only a partial target can be determined in order to figure out the initial central coordinates of the target. Here the detection range of which camera is in use can be determined, the extension of the searching frame with radius dr from the search center (x_0,y_0) is where the target may occur, then ROI (region of interest) is defined in order to determine the actual position of the target.

The color component is added for binarization to improve positioning accuracy. LUT A_3 , A_4 , A_7, and A_8 are used for determining the corresponding optimal threshold, corresponding coordinates (x,y), and the optimal threshold of the r and g components of the target. After locating the center point of the target object image, the actual corresponding coordinate position of the object in space can be obtained through the alternately-eight-matrix look up table method. A_1, A_2, A_5 and A_6 represent four position mapping matrices for camera <a> and <b>, respectively.

3. Experimental Results and Discussion

When this experiment was positioned at a spatial location, set LUT as r component and g component threshold to remove the complex background environment and non-uniform light field affects. Figures 2(a)~2(h) show the variance in the position of the yellow ball target, with and without polarizer sheets in the same blue background. Different threshold conditions are used for background segmentation. Figures 3(a)~3(d) show that the background is clearly separated, whereas, and Figures 3(e)~ 3(h) show that the background is incompletely separated.



(a) (b) (c) (d)

(e) (f) (g) (h)

Fig. 2. (a),(b) CCD-<a> (c),(d) CCD-<b> variance in position of yellow ball target with polarizer sheets (e),(f) CCD-<a> (g),(h)CCD-<b> variance in position of yellow ball target without polarizer sheets.

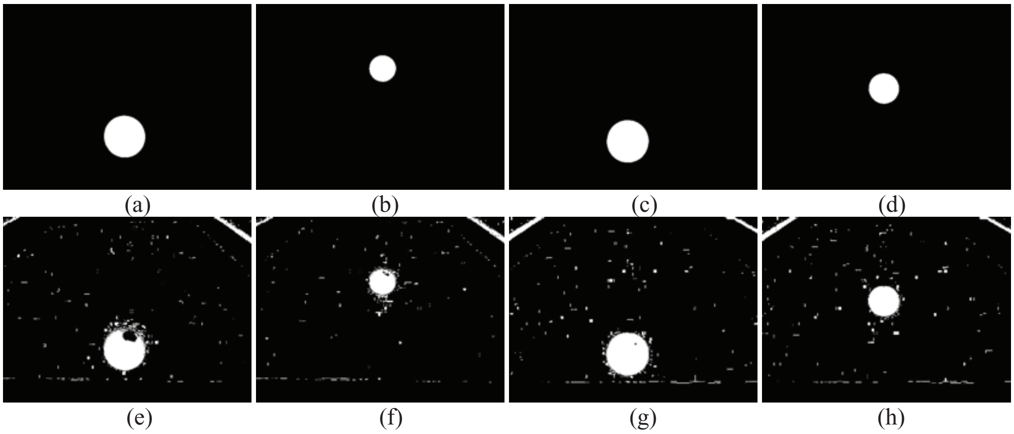


Fig. 3. (a), (b)CCD-<a>: Binarization using optimal threshold of r component
(c), (d)CCD-<b>: Binarization using optimal threshold of r component
(e), (f)CCD-<a>: Binarization using simple thresholing
(g), (h)CCD-<b>: Binarization using simple thresholing

4. Conclusion

The system developed by this study can be used for real-time position fixing measurements, for the positioning of a target in a large screen or region, and be applied to interactive games. Two cameras are placed at both sides of a fixed range, thus, optical-field distribution binarization can be carried out using the developed threshold look-up table to determine the target position. This system has the advantages of a wide range, high accuracy, quick response, no dead angles, and low cost. The threshold LUT method has been developed, which can carry out binarization of light field distribution. The experiments proved that this method can effectively overcome the difficulties associated with binary processing that are due to poor image quality.

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