

A User-Friendly Presentation System

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ABSTRACT

Over the years, teaching methodologies have developed from white chalk board to projectors to smart online teaching now. All the practices except projectors involve direct contact with board. In a typical presentation, a presenter has to depend on an operator to control the functionalities of a mouse. And in a worse situation where he has to operate all by himself, he is compelled to interact with a computer more than the audience. This paper aims at developing a handheld laser device incorporated with buttons for left and right clicks to emulate the working of a mouse. A camera captures the image of projected screen continuously. Through Digital Image Processing (DIP), the location of laser is analyzed along with the clicks and this information is communicated to the PC to operate. This project also aims towards the advancement of projector usage by correcting keystone automatically and the tasks of remote control are achieved by commands given by user through keyboard interface. Thus, the remote to control projector can be excluded.

Keywords: Human Interface Device, Bluetooth, Open Source Computer Vision Library.

1. INTRODUCTION

Laser pointers were developed originally in 1980s. Lasers are found in an incredible range of products and technologies. They are widely used for their monochromaticity and spatial coherence. The low-power laser remote modules only enable us to change the slides with a laser beam to point out. Sometimes, the presenter has to open folders and other tasks during his presentation. This paper explains about a handheld device emitting laser beam to control the position of cursor. Any operation like single click, double click, right click, select, scroll and drag can be performed by the presenter at ease. A camera, mounted on the projector captures the images of screen at around 20 frames per second. The general architecture and technique for image processing is used to get the laser pointer's location. When a button is pressed, the click data is transmitted wirelessly to the main processing unit. The combined clicks data and location data transmitted via Bluetooth to PC as HID mouse data. Here, Bluetooth acts as Human Interface Device (HID). Thus, mouse pointer is made to trace the laser pointer's path. Open Source Computer Vision Library (OpenCV) is required for easy image processing techniques

2. OVERVIEW

In the present paper, we have developed a completely automatic system. All the previous works require user intervention for the system to work like giving inputs of corners, etc.[1, 2]. The previously proposed systems involves high cost to implement [3] and the laser point detection algorithms are complex [5, 6] and unstable in dynamic environment [8]. The simple hardware architecture is shown in Fig. 1.

2.1. Hardware

A MSP430 Launchpad interfaced with three buttons, for left, right and center clicks respectively, is shown in Fig. 2. This microcontroller unit encrypts the mouse-click data and sends it to the RF transmitter (CC2500 transceiver module). At the receiving end, another CC2500 receives the data and gives it to the Raspberry

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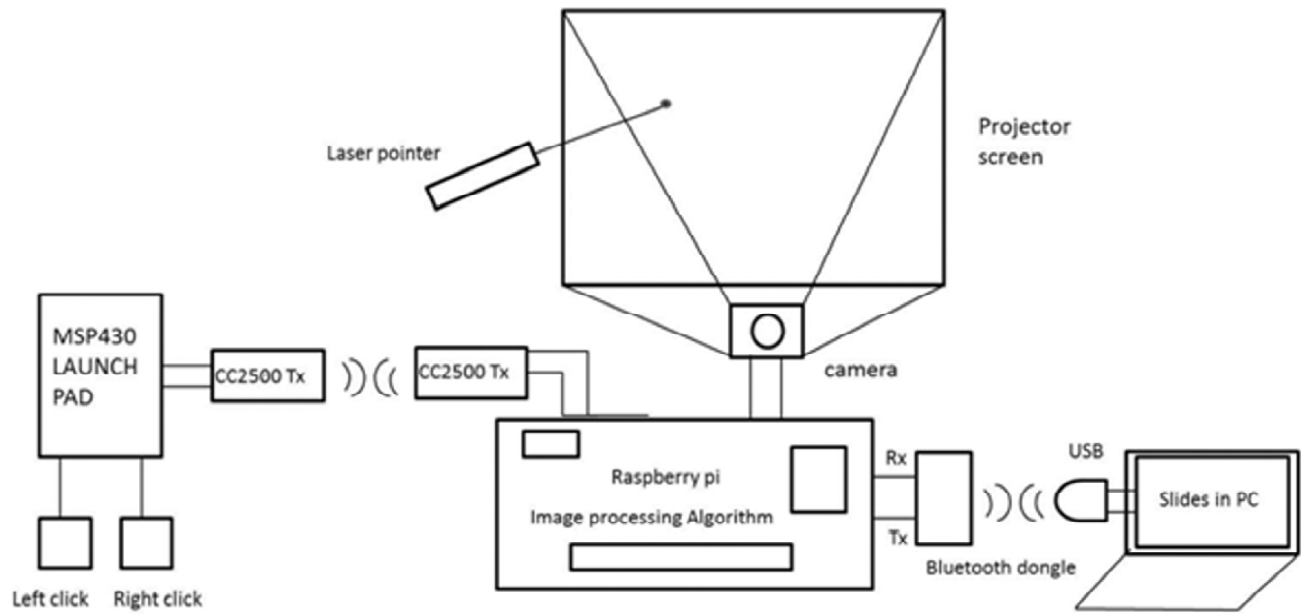


Figure 1: System block diagram

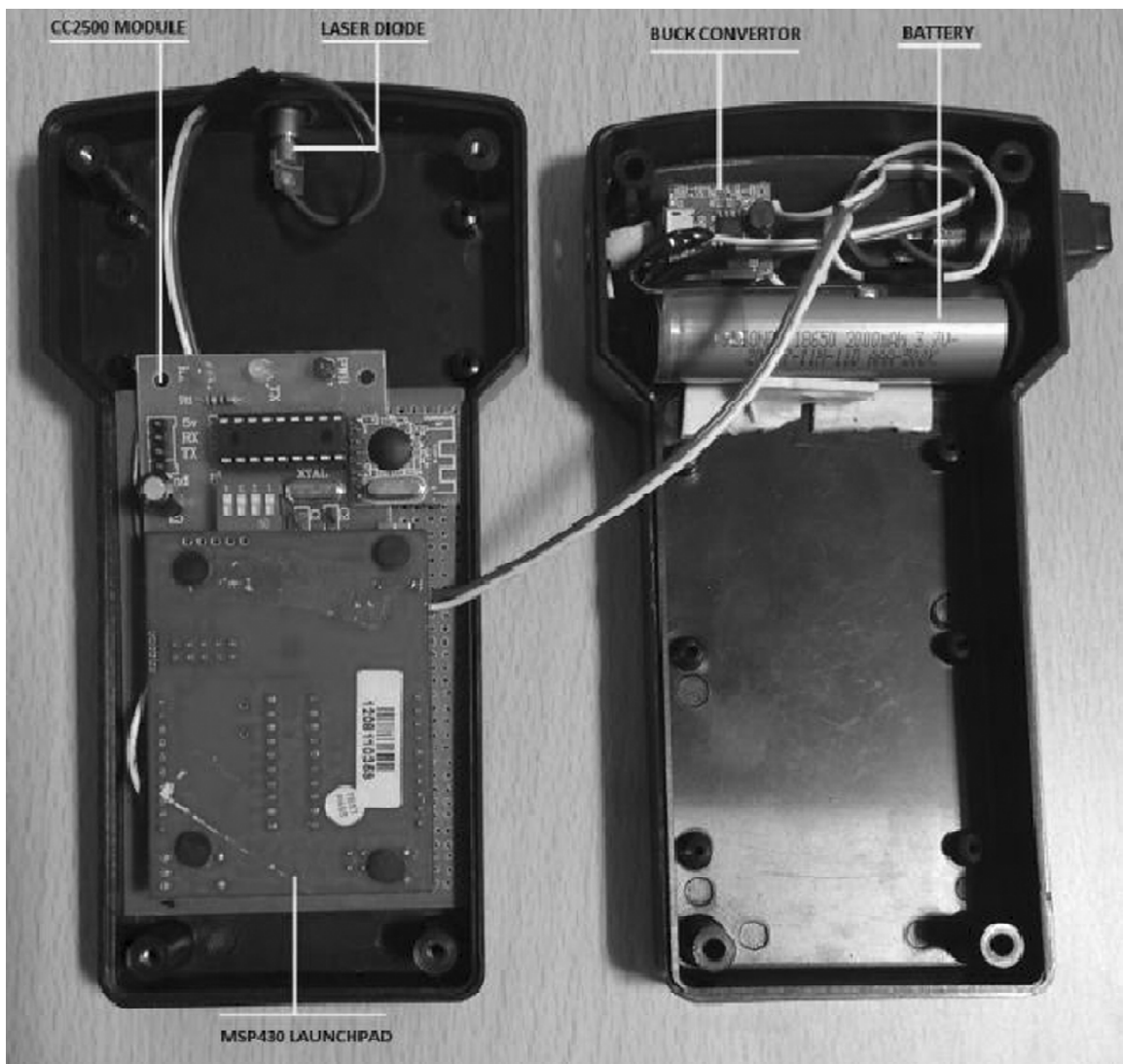


Figure 2: Components of hardware module

pi unit for decryption. This standalone device, Raspberry pi acts as the Human Interface Device for the PC host. A camera (Logitech, c920 HD camera) captures images at 25 frames per second. The images received are processed through OpenCV platform in Raspberry Pi. The (X, Y) coordinates obtained from Digital Image Processing (DIP) along with the mouse-click data from the Launchpad are then transmitted to the PC host system via Bluetooth. Finally, Raspberry pi is configured as Bluetooth HID device.

2.2. Laser Spot Detection

Various image processing techniques such as edge detection, special filters, image warps are used to derive this robust algorithm:

1. Capture the projected screen image.
 - Extract the red channel alone from the captured image.
 - Find the maximum value in the extracted red channel.
 - Threshold the image with value (max value 5) to find the laser pointer
 - Draw the contours on the obtained resultant image.
 - If number of contours is 1, set the flag.
 - Else move to next step.
2. Make a copy of the captured image.
 - Convert the frame into HSV channel
 - Split the same into 3 channels
 - Take value channel alone into consideration
 - Check if contour's area and arc length lies within the specified range
 - Obtain binary image using inrange function by passing brightness value for
 - thresholding.
 - Draw the contours on the obtained resultant image.
 - If number of contours is 1, set the flag
 - Else move to next step.
3. Do the following with a copy of initially captured image.
 - Convert the frame into HSV channel
 - Split the same into 3 channels
 - Take all 3 channels into consideration
 - Check if contour's area and arc length lies within the specified range.
 - Obtain binary image using inrange function by passing scalar value for thresholding
 - Draw the contours on the obtained resultant image.
 - If number of contours is 1, set the flag
 - Else move to next step.
4. Perform AND operation between available contours obtained from the above steps.

- Check if contour's area and arc length lies within the specified range.
 - If number of contours is 1, set the flag
 - Else check for the contour's area and perimeter to obtain the laser pointer and set the flag.
5. If the flag is set, move the mouse pointer to the particular coordinate.
 6. Restart again from step 1.

One of the challenges faced while detecting the laser point is jittering. Jitters are involuntary small handshakes that vary with each individual. But they become predominant while pressing the buttons and when the device is operated by old people. There are many filters to overcome this. But the most reliable and accurate one is Kalman filters.

2.3. Eliminate Remote Control

LIRCD daemon is the important part of LIRC (Linux InfraRed Control) that receives and decodes the signal. The button values are first recorded by pointing remote controller at Pi; IR sensor decodes these signals to store it under a command name. Later, IR LED is connected to pi controller to pass commands to projector. When a command is passed through keyboard interface or even press of a button, the projector obeys to the recorded function. Fig. 3 shows an example of recorded values.

```

pi@raspberrypi: /etc/lirc
GNU nano 2.2.6 File: lircd.pioneer

begin remote

  name      Pioneer
  bits      32
  flags     SPACE_ENC|CONST_LENGTH
  eps       30
  aeps      100

  header    8495 4260
  one       530 1589
  zero      530 535
  ptrail    542
  gap       89638
  toggle_bit_mask 0x0
  suppress_repeat 2

  begin codes
    KEY_VOLUMEDOWN      0xB54AD02F
    KEY_VOLUMEUP        0xB54A50AF
    KEY_0                0xB54A48B7
    KEY_1                0xB54A30CF
    KEY_2                0xB54A7887
    KEY_3                0xB54AB847
    KEY_4                0xB54A38C7
    KEY_UP              0xB54A02FD
    KEY_LEFT            0xB54A42BD
    KEY_RIGHT           0xB54AC23D
    KEY_DOWN            0xB54A827D
    KEY_FN              0xB54A9867 0xF50AE619
    KEY_AUDIO           0xB54AB04F
  end codes

end remote

```

Figure 3: Recording button values using LIRC package

2.4. Automatic keystone adjustment

To correct a keystone image, two methods are commonly used: (1) by using a corrected image for calibration, (2) by using the borders of the projector screen as calibration. Using borders of the screen is preferred since it is more accurate and less time consuming. But when the borders are absent the first method is used.

1. Initially the user has to take an image of the projection when it is in perfect rectangular form. This image is used as the calibration unit. From the calibration image, the top and bottom edges are found out. Their lengths are saved. When the keystone correction is required, the user will press the left button in the LAMO main unit. This will cause an interrupt which will call the keystone service routine. The following is the algorithm to process the calibration image.
2. The red image projected is then captured. The following pre-processes are executed.
 - It is converted to grayscale.
 - The grayscaled image is then thresholded.
3. The binary image after thresholding is then sent for corners detection.
 - The corners are detected using the OpenCV function `goodFeaturesToTrack()`. This will find a total of 20 corners among which the four corners of our quadrilateral is present.
 - From these 20 corners the top left and bottom right corners of the projection are filtered out.
 - The product of the x and y coordinates of the found corners are calculated.
 - The coordinates having the largest product are the coordinates of the top left corner.
 - The coordinates having the smallest product are the coordinates of the bottom right corner.
- 3.1 This step is to find the remaining corners, that is the top right and bottom left corners.
 - The thresholded image is flipped and sent again for corner detection. Steps from 3.1 to 3.3 are carried out again.
- 3.2 Then the top left and bottom right corners are scaled to bottom left and top right corners respectively by subtracting the y coordinate value from the total height of the image.
- 3.3 After finding the four corners, the lengths of the top and bottom edges are found out by distance formula.
4. These lengths are stored as the calibration lengths of top and bottom edges.

The following algorithm describes processing images in real time against the calibrated image:
- 4.1 Once the button is pressed, capture the red image projected by the projector.
- 4.2 It is converted to grayscale and is thresholded.
- 4.3 The binary image after thresholding is then sent for corners detection. Four corners of the quadrilateral to be correction are detected. Refer Step 3 of Processing the Calibration Image for detailed explanation of corner detection.
- 4.4 The top and bottom edge lengths are calculated by distance formula.
- 4.5 Now compare these new edge lengths with the calibration edge lengths and decide whether to increase or decrease the keystone.
- 4.6 Then find the sum of the differences between the new top edge and bottom edges and calibration top and bottom edges respectively.
- 4.7 Divide the difference in edge lengths by a factor 0.4. This will give the number of times the keystone has to be changed. This will bring the keystone closer to the corrected value.

Then another frame is captured and steps 2 to 7 are executed. This will keep looping until the difference between the new edges and calibration edges are approximately zero.

The keystone correction service routine will capture the screen along with black borders. In this captured frame, bottom edge and both the edges on sides are retrieved and angle between them are calculated. These angles are compared with the displayed red image to obtain the number of times the keystone has to be varied. It is similar to previous algorithm except the formula for calculating keystone:

$$\text{Keystone} = \frac{\text{Difference between angles}}{0.2}$$

3. RESULTS

Other parameters to assess this system are discussed below:

3.1. Accuracy

Accuracy is expressed with the difference between the laser pointer and actual position of cursor. After implementing Kalman filter, its accuracy improved considerably.

3.2. Latency

From turning on the projector to adjusting the keystone image it takes 15 seconds at an average and around 30 seconds in worst situations. Besides, to move the cursor point to laser point position it hardly takes a second.

3.3. Cost-efficiency

A wireless Logitech presenter which has a laser diode and used to change slides alone costs around Rs. 5000. But the cost in making this hand held device that offers multi-features is estimated to be a little less than that as shown in Table 1.

Table 1
Cost Details

S. No	ITEMS	COST (in Rs)
1.	Raspberry pi board	2500
2.	Bluetooth dongle	200
3.	MSP430 Launchpad	660
4.	CC2500 module	1200
	TOTAL:	4 560

4. CONCLUSION

The image processing algorithm was derived to work in most of the test conditions using OpenCV and also the jitter problems in LASER point detection was eliminated. All the projector settings is now controlled through means of an IR LED driven by raspberry pi. One of the challenges in implementing this system was to establish communication between various devices.

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