Camera Based Interactive Wall Display With Hand Detection Using LED Lights

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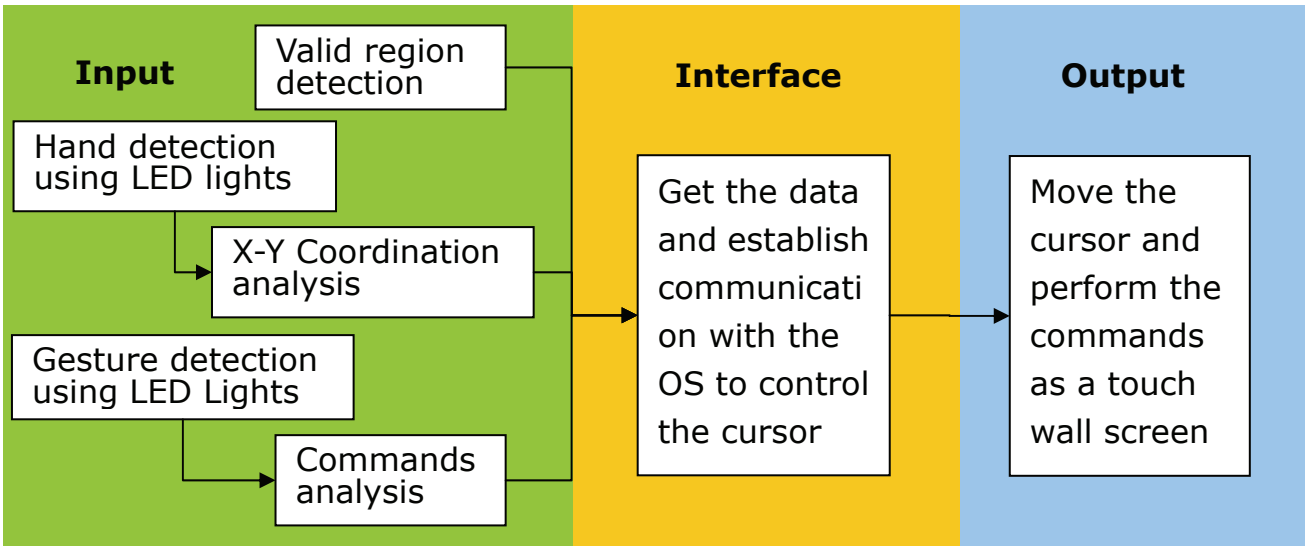
Overview

There are many different ways to manipulate OS, we can use keyboard, mouse or touch screen. When doing presentation, it is inconvenient to control the OS and present at the same time. Our system, interactive wall, allows you to use hand to control OS on the projection screen but not touch screen. You can now experience a new way to control your cursor.

Our system can be applied to the existing equipment, so we don't need to purchase any expensive touch screen. The system requires one web camera to detect the hand and then you can start to experience our system. Also, three LED lights are required to put on the fingers to help the system to detect the location of the hand and the gesture performing.

The physical equipment is not restricted. Any size of projection screen can be set up for the system or you can use a wall or a table to project the screen. User can be more flexible to enjoy our interactive wall in any places.

System Design

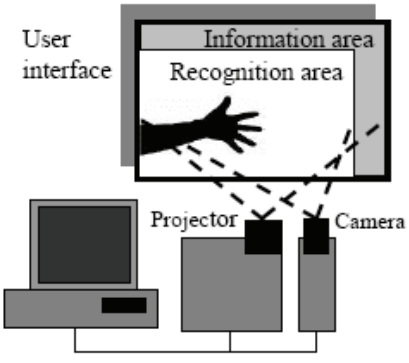


Input

Input includes valid region detection, hand detection and gesture detection. The system first implements valid region detection to achieve the display screen resolution and it identifies the x-y coordinates in the captured image on the screen. Then it recognizes the hand's shape and location and passes the x-y coordinates to the interface/output part of the system. Since the user may use different hand gestures to control the virtual mouse, the system detects and interprets specific hand gestures and passes the respective command(s) to the interface.

Interface / Output

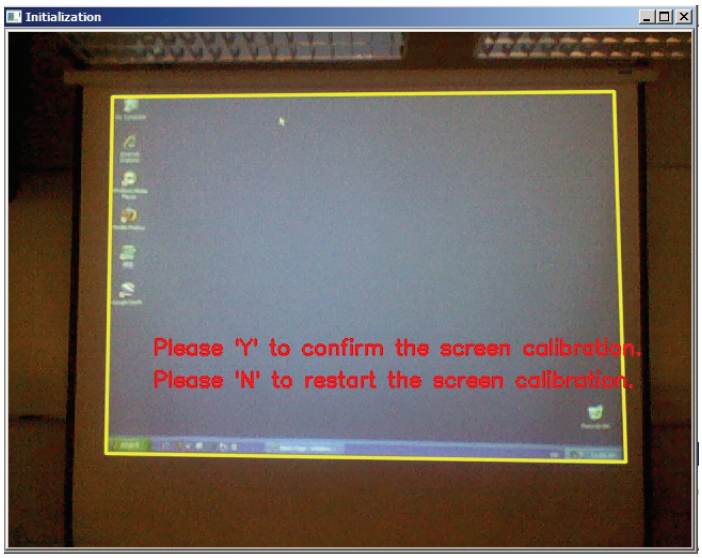
The interface is the device that can communicate between the recognition part and the OS. After the input part passes the data to the interface, the interface performs the action immediately and produces associated output.



Valid Region Detection

In order for the system to be interactive, it requires real time processing and also synchronization with human hand gestures. In order to do this, we carefully identify the projected area for accurate positioning of the cursor in the design phase. If the hand is out of the projected area, then all the gestures or commands are invalid. The system only executes the commands when the hand is inside the projected area.

Since the projected area must be a rectangle, we decided to use this characteristic to identify the area. By using the contour finding function (i.e. ***cvFindContours***) from OpenCV, it was easy to find out four end points (i.e. the 4 corners of the projected area) of a contour.



Hand Detection Using LED Lights

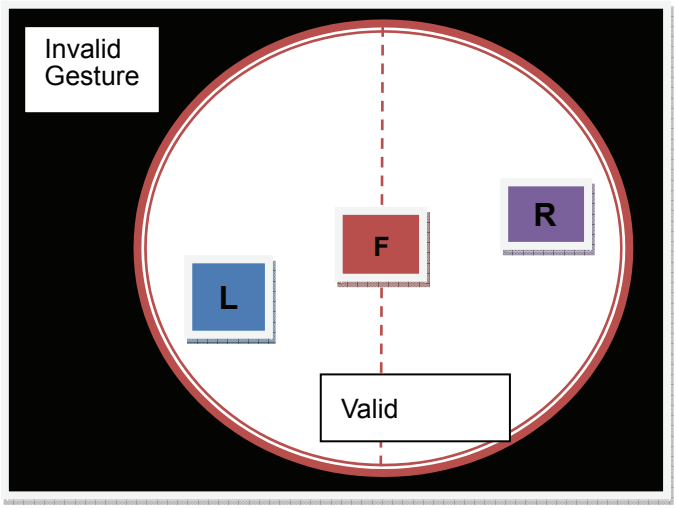
LED lights provide a stable and efficient way to locate the position of the hand. The system only requires three LED lights because this number of lights provides sufficient commands and no interference affects the control.

Motion Detection is a supporting part of the hand detection. The algorithm compares two images and sees if there is a difference. Due to most noise and objects being in fixed positions, they can be easily removed with this method.

After filtering the noise, it is assumed that only the light from our device is left in front of the screen. By collecting the entire contour from the images after the motion detection, we know the positions of the LED lights on the fingers. Then the system uses an array to store the position of the hand. That means that the array saves the current location of the hand. For each image from the camera, the system loops all the contours in the new image to see whether there is movement of the hand. If movement is within a fixed range, the array is updated for the new position of the hand. The reason for setting up a range is to prevent a sudden disturbing light from appearing on the screen. If noise appears suddenly far away from the hand position and the noise position is out of range, then the array will not be updated for the position. It can thus eliminate unwanted updating of the tracking array.

Gesture Detection Using LED Lights

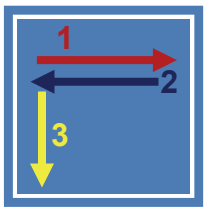
After the hand detection, a maximum of three light sources can be detected: (i) the light that is closest to the track point is the first light F; (ii) the second light at the left hand side of F is L; (iii) the third light at the right hand side of F is R. We can imagine that F is the center of a circle with a certain radius. L and R will appear inside circle and be regarded as valid gesture commands.



The system relies on F, L and R to determine the actions. When only light F appears, the cursor synchronizes the position of the light on the projection screen. When light L appears on the left hand side of light F, then left click is executed. When light R appears on the right hand side of light F, then right click is executed. If three lights appear for a second, then the function of scrolling is executed.

Since L and R can appear on any left part and right part in the circle respectively, it is difficult to keep tracks of L and R. Only F can be kept track of and used as the input method.

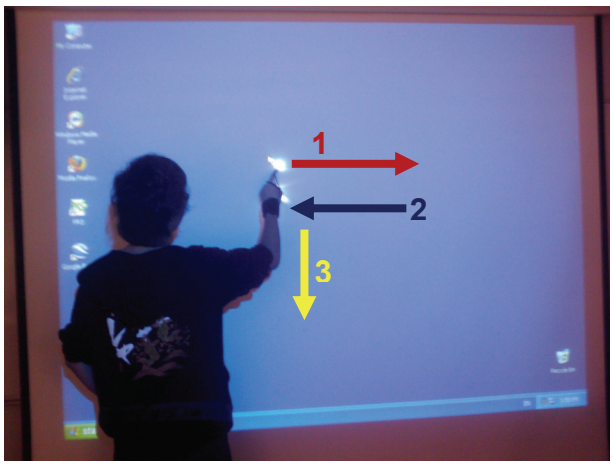
The system analyzes the direction of movement of the track point and compares it with the pre-define pattern. If the input and the pattern match, then the corresponding command will be activated.



Cursor Interface

After the system figures out the light F at the captured image (x1, y1), then the system needs a ratio to synchronize the X-Y coordinates accurately on the display (x2, y2). The algorithm of calculating the ratio of the width and the height (w, h) is the size of display screen resolution divided by the size of valid region. Then, the system can position the cursor at the right place (x2, y2) by calculating the formula (x1 * w, y1 * h).

Cursor interface provides different commands, such as (i) basic movement and actions; (ii) the user's pre-defined programs, and simulation of a keyboard by performing the user- defined special moving patterns (e.g., Right -> Left -> Down).



Conclusion

Our product, an interactive wall, can provide a new, user-friendly, fast and accurate classroom presentation tool. However, we believe that it still has room for other improvement, and we hope that other new camera-based products can be produced based on our idea.

For more details, you are welcomed to surf our site: http://sites.google.com/site/tkp98099/.