IJARCCE
ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 3, March 2017

Laser Projection Virtual Keyboard: A Laser and Image Processing based Human-Computer Interaction Device

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Abstract: Todays QWERTY Keyboard have large size and can hardly be modified. As the size of desktops and laptops is decreasing day by day, the traditional keyboard acts as an obstacle in the path of the further minimization. Virtual Keyboard having a compact size may be an appropriate solution to the drawbacks with the traditional keyboard. Currently many 3D Camera based virtual Keyboard exist. This paper's main aim is to create a Virtual Keyboard with minimum hardware, easy to use and configure options for future improvements too. It uses a standard web camera. The main focus of this project is to demonstrate use of Laser Projection Virtual Keyboard in place of Conventional Keyboard and to flash a light on current Virtual Keyboard. The layout of the keyboard is generated using laser projection. Importantly, it can be easily reconfigured to act as a replacement to theconventional English Keyboard projection using many different languages inputs allowing multiple language typing.

Keywords: Virtual Keyboard, QWERTY Keyboard.

I. INTRODUCTION

Being a part of this era of virtual reality who is not known to a device like Virtual Keyboard.A Laser Projection Virtual Keyboard is simply a keyboard projected and touched on a surface. A virtual keyboard can be consideredas one of the best or we can say finestexamples of today's fast moving trends. Computing is not just limited to laptops,PCs; it found the ways to enter into many devices for instance mobile devices like cell phones and palm tops. The only thing which remains stagnant is the old QWERTY keyboard which we have been using since the time computers were invented, for whichthis virtual keyboard (VK) technology is requiredas a latest development.

The first and the foremost problem in normal QWERTY keyboard is its size, it's large in size and it's really very inconvenient for a person to carry it, there are chances of breaking it while carrying.The second big problematic situation for it is its language restrictions, auser has to installand loadvarious different software's to communicate with the system in any type of other language (English is default language).

Our paper brings into light a brand new technology to those people who are fascinated about using a new era Virtual Keyboard using any sort of surface. Virtual keyboard allows every user to have a multilingual writing content and text content on any of the existing platforms. The idea behind creating this virtual keyboard is that is it's small, well designed, handy and really very easy to operate also, which results in the perfect solution for cross multilingual text input.

II. RELATED WORKS

Keyboard plays an irreplaceable role in many areas such as data input and the transmission of signal control etc. However, traditional keyboard is bulky and is inconvenient to carry, failed to meet the demand of today's era. The appearance of Laser Projection Virtual Keyboard presents a latest solution for input on personal computers and portable device too.

Various latest techniques have been adopted on the design schemes of virtual keyboard such as brain-computer interface and gesture recognition. Reference [1] developed a drag-type mode based on touch screen techniques to take the location of the keystroke in smart mobile phones. Reference [2] discussed a brain - computer based virtual input system. It acquires eye-gazed characters through electrooculogram (EOG) & electromyogram(EMG) signals, and gaining the angle of sight, recording brow muscle activities for verifying. The sampling frequency was up to 176 Hz and the classification accuracy reached up to a mark of 95%.

Reference [3] came up with a multi-touch virtual input system. Exactly different from brain-computer based interface, some special gloves and other modules, the visual-based virtual keyboards don't require any kind of equipment to wear or maintain size, and therefore it has brighter future.Compared to the above-mentioned virtual keyboards,our virtual keyboard system that we have proposed through this paper is more of a QWERTYtype keyboard. It (our system) does not only provide convenience, but also some speed which meets theneed of fast or normal typing. Because of Image Processing technology, there is no add-on to our Virtual Laser Projection keyboard for users.

DOI10.17148/IJARCCE.2017.6379

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Reference [4] had proposed detecting the fingertips in form of 2Dimages using a pair of cameras, and then the fingertip positionin 3D space would be determined using triangulation method.Some similar and excellent works have been done in field of Virtual Keyboards.Compared to the system with 3D technology, our systemonly utilizes one camera. So it's cost effective. In this paper, weresearch how to get a clear fingertip image, examine thecorrect rate and analyse the cause of errors.In our paper, the concept of virtual keyboard system aggregates laser with image processing technology. And thesystem uses embedded-system to build a compact, portable and handy input device.

III. MODELS AND ARCHITECTURES

In the proposed system, Waterfall Model andSpiral Model have been used. Using many models we have made a Virtual Keyboard architecture:

A. Basic idea of Touch Detection and Architecture:
We use click or touchi.e. shape characteristics for touch detection. There is a complete change inshape of projected interactive elements at the time we touch itby the fingers[5]. Detecting the distortedinteractive element is an important method to monitor the touches.

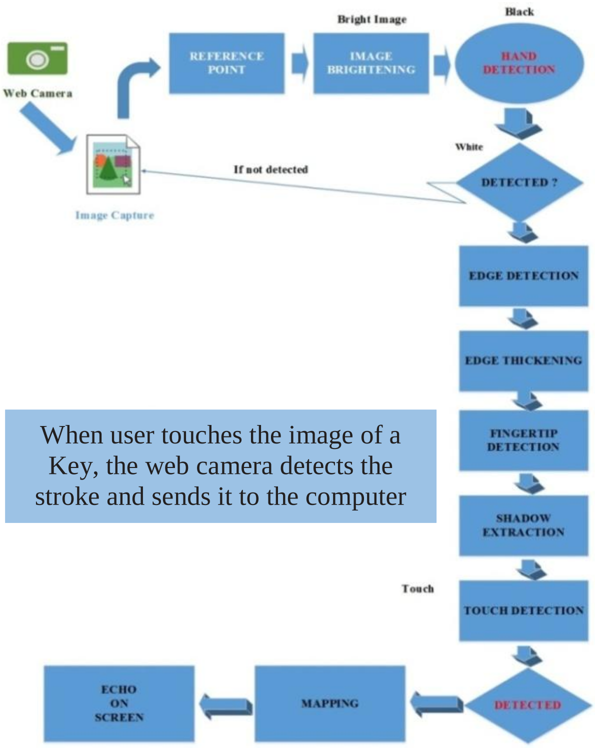

Figure 1 Virtual Keyboard Working Architecture

IV. PROPOSED SYSTEM

The proposed system would have a front end that would work as an interface to initialize the keyboard to any sort of new environment [6]. Any projected image or surface can be a reference and a photo of the same is stored in the memory as a reference image. This referenced image would be segmented using the thresholding technique. On execution of the code we have written, we would be able to recognisethe differences in this image by comparison with the original image already stored in our system's database. After the detection ofsegment where the changes occur, a type of virtual key press would be initiated accordingly.
The current function of each particularkey would be displayed for the sake ofconvenience of user and can be altered according to user's preferences.

A. Frame Grab: Firstly a constant video feed's obtained using the webcam connected to the PC [7]. A webcam's interface controllingAPI is used for this. At some regular intervals (about 10 to 15 times every second), the current frame from the video is being copied as image to some other image control wherein we can read or manipulate the pixels from that image.

B. Pre-Processing: An image processing filter (pre-image processing) is applied to the image (input image) so as to improve it for the further processing that is to be done in next steps. Here either image is made blur in case it looks too sharp or the image in sharpened in case the video feed's too blurred [9]. Hence either the Gaussian blur or sharpening filter is performed, based on quality of feed.

C. Selective RGB& RGB-HSV Conversions:The images captured by the camera are colored. These images are converted to intensity (luminance-Y) values. This is done in accordance with the requirement of the algorithm as it may create unnecessary complications while dealing with the R, G, and B (Red, Green, and Blue) values of each pixel of a colored image. By doing this we are simplifying the process of detection as we need to deal with only single value instead of three different values. Thus, processing time is reduced by a factor of three.The formula required for conversion of R, G, and B to luminance values is shown in equation [8]

$$Y = (0.299*R) + (0.587*G) + (0.114*B) \quad ..(1)$$

Here R, G and B are Red, Green and Blue pixel values respectively, which are obtained by the image captured by the camera. These Y values are stored in memory.

D. Segmentation: In this step, the grayscale image obtained in previous step is processed for discriminating the point of contact of fingertip from the remaining image. The image obtained in this step creates a region of interest (ROI) for the next step which is feature extraction.
The converted grayscale image is now scanned according to rows starting from the top-left pixel toward the pixel at bottom-right. The difference between the intensity value of the current pixel located at (x, y) and the intensity values of the pixels located at (x, y+δ) and (x+ δ, y) are

DOI10.17148/IJARCCE.2017.6379

calculated for each pixel as made known in equations (2) and (3)

$$Y_{\alpha} = Y_{(x,y)} - Y_{(x,y+\delta)} \quad \ldots\ldots (2)$$

$$Y_{\beta} = Y_{(x,y)} - Y_{(x+\delta,y)} \quad \ldots\ldots (3)$$

The value for δ is found to be 5 from experimentation. A particular threshold θ is decided on the basis of which the intensity value of the pixel located at (x, y) is determined. If the values of Y. α or Y β are crossing the threshold value then the intensity of this pixel is set to 255(white), else if the obtained values are below the threshold then the intensity is set to 0(black). The above discussed condition is discussed in equation 4.

$$Y(x,y) = \begin{cases} 0, & Y_{\alpha} \le \theta \ or \ Y_{\beta} \le \theta \\ 1, & Y_{\alpha} \ge \theta \ or \ Y_{\beta} \ge \theta \end{cases} \quad \ldots. (4)$$

E. Feature Extraction and Noise Removal: The exact location of the touch point of the fingertip on the surface is determined. The surface is considered as a two dimensional plane where limits of x and y depends on the resolution of the camera used to capture the image. Thus, using this algorithm we can find the Cartesian coordinates (x, y) for individual touch points.

In the previous step a segmented image is obtained which is now scanned row-wise starting from top-left pixel until bottom-right pixel is scanned. The fingertips are represented by white arcs in the segmented image. Thus, in order to determine the location of the touch, as soon as the algorithm encounters a white pixel, it checks whether following five pixels are white pixels or not. If the algorithm encounters five continuous white pixels in the same row, it is registered as a point of touch and its coordinates are saved.

A few outlying white pixels may be encountered in the segmented image while the algorithm scans the image and they could be considered a point of touch, but this algorithm is accurate and efficient enough to reject such noise from the image as they may cause large variations in the final result.

F. Histogram:A binary histogram for particular character is constructed. Histogram is the frequency count for the pixels (which may either be completely dark or completely white after the Thresholding process).

G. Pattern Matching and Recognition: A number of steps are performed to match the pattern stored and input given by user to recognize the exact pattern. Thenfinally by using the Robot API, the output keystroke is analysed [10].

V. CONCLUSION

We have proposed a Laser Projection Virtual Keyboard based particularly on image processing techniques and MATLAB. In the proposed system, a laser projection device and camera along with an interface software is used to implement a new era virtual keyboard. This system consists of four main stages: keyboard detection, hand detection, edge detection and mapping. Image processing technique uses HSV and RGBcolour models with given conditions to extract shadows, tip detection and mapping. Frame grabbing technique is used to capture frame sets and interpret the right key pressed. Our system will work very well when provided with an appropriate surface, a good resolution 2D camera and a system with fast processing speed(to take numerous frames per seconds), resulting in significant increase in use of this new hi-tech Laser Projection Virtual Keyboard. The overall accuracy of our proposed system would be improved and enhanced in accordance to increase in the processing speeds, demonstrating its effectiveness and usefulness too.

VI. FUTURE SCOPE

In future work, we will implement the special characters (*,^, etc), numeric keypad and different shortcuts such as cut, paste, or copy i.e. two or more key presses simultaneously. The relative speed of capturing the frames may be slow and it may happen that the system may skip one or two characters pressed. To improve the performance of our proposed system it's required that we have higher processing speed computers or laptops. The frame capturing speed and the performance of image pixel capturing can be furthermore improved by using a higher resolution and more megapixel 2D camera. Implementing a virtual keyboard is a challenging task and is most likely to be not favoured compared to conventional keyboard as we have become so used to it.But our proposed system is definitely a step towards a new future in computer world.

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