VIRTUAL WIRELESS KEYBOARD SYSTEM WITH CO-ORDINATE MAPPING

Souvik Roy, Ajay Kumar Singh, Aman Mittal, Kunal Thakral
Department of Electronics and Communication Engineering,
Guru Gobind Singh Indraprastha University, New Delhi, India

ABSTRACT
This paper presents more efficient algorithm used to detect the finger stroke of a projected keyboard layout on any flat non-reflecting surface. The virtual keyboard consist of variable intensity projector for projecting keyboard layout, a Camera with infra-red filter for capturing only infra-red wavelength light reflected objects, an infra-red Diode for object detection, photo-diode with simplified circuitry to on-off the key stroke detection and key board layout projection. The camera used is connected to PC or laptop with a wireless connection operating at 2.4GHz frequency of IEEE standard. An image processing algorithm is designed in open source to extract the keystroke on the surface and display the exact key on the screen. The integration of components with the software that is designed to run on any Operating system with even lower level of processor gives expected keystroke. Comparison algorithm calculates and checks the nearest value suitable for key injection to the system API. Height of device made has been kept as low as possible so that it does not interrupt the view of display screen of laptop or PC. Present work can be more upgraded with more gesture based feature that controls the virtual keyboard device and making the extra surface for virtual mouse option.

KEYWORDS: *Keyboard, Object Detection, Finger Detection, Camera, Infra-Red Filter, Frame Capturing*

I. INTRODUCTION

With an increasing demand for switching into new and virtual environment from the old physical environment where hardware ware out has been a problem due to continuous use of it. Virtualization [1] of keyboard to display has been carried out since decades but the precision of functionality has become a problem. Virtual keyboard is the most important part of virtualization as it cannot be obsoleted from the computer part. Hence there is a need for upgrading the method of keystroke detection that will make it more precise and adapt to human tendency of pressing.

II. DESIGN

The design of the Virtual keyboard system consists of minimum use of hardware devices and maximum dependence on software algorithm.

2.1. System design

Virtual keyboard system is designed keeping in mind the maximum efficiency of algorithm [2] and lower error rate that will not make user feeling different response rate then physical keyboard. The design consists of following modules:

- CMOS wireless camera
- Infra-red band pass filter
- Keyboard Projector with intensity control
- Infra-red laser diode
- Double Concave lens
- Diffraction grating
- Holographic film

- Current controller circuit
- Software for Key-stroke detection
- LM-1117 voltage convertor

All these modules are used to design a proper and highly efficient system.

2.2. Hardware design

The Hardware of the system is most important part of the system as exact configuration of components is required to simplify the algorithm and error rate. The first sensor part of the system CMOS [3] wireless camera is integrated with Infra-red band pass filter which limit the camera sensing capacity to only Infra-red light. Limiting the sensing capacity of camera is useful in detection of finger touching the virtual projected keyboard layout as it is the least interfering light in any environment that could generate error and algorithm more complex. Second part of the design is the Keyboard projector [4] that is used to project a fixed designed keyboard with two different language characters printed on them. This projector projects a visible laser beam passing through biconcave lens [5] and a holographic [6] keyboard layout plate thus projecting the shadow of keyboard. The intensity of the laser diode is controlled by limiting the current flowing to the laser diode. Current limiting is controlled through current controlling circuit which consist of variable resistor to change the intensity of laser diode. The third part of the design is Infra-red laser diode that is used to generate a layer of linear Infra-red light parallel to the surface on which keyboard layout is projected. Since the infra-red laser cannot emit a linear diffracted [7] beam to cover the whole keyboard layout without diverging. Therefore we need to pass the laser light through Biconcave lens adjusted in such a distance that emerging of parallel laser beam to pass through Diffraction plate which diverge the beam linearly hovering over the whole surface of keyboard layout.

2.3. Software/Algorithm Design

The design of software starts from the image processing algorithm which is the most important part of key-stroke detection. Now the camera is only able to detect objects blocking infra-red light from the Infra-red laser [16] beam plane or objects emitting infra-red light in the camera field of view. Starting with capturing image frames from a CMOS camera and transmitting frames through Wi-Fi [8] network to the laptop or PC using frame capturing code written. This capturing of image should be such that the generated image is mirror image of the original image. Image frames generating from CMOS camera consist of infra-red images as the camera lens is integrated with infra-red band pass filter. The image contains lot of noise and high frequency regions where object edges to be extracted, therefore a two steps are performed before moving into key-stroke detection. Firstly Gaussian [9] filter is used to remove the white noise that is present everywhere in the whole frequency range of image spectrum [10]. It also has linear graph according to which there is no sharp/abrupt change in frequency band, thereby increasing the accuracy of detecting sharp edges of object which are generally in high frequency region of image histogram. Secondly threshold function is used to omit the region of non-object and showing the region of objects touching the surface. Key-stroke detection is started with point of interests extraction where centroid of all the touching points is calculated using cvFindContour [11] function. This function provides a co-ordinate that is average area of the finger tip. The co-ordinate value extracted is need to find out for actual key pressed at that location, which is done through a method of predefined [12] keyboard with fixed key co-ordinate location are stored in a one-dimensional array. The mapping of generated co-ordinate with beforehand preserved co-ordinate of keyboard pattern is done through comparison of co-ordinated to find out minimum difference of displacement between co-ordinates. This comparison does a very efficient computation as uses tree [13] structure for comparison. After the comparison of co-ordinates the nearest key value is found out which is injected into Operating system through available API for windows system allowing to inject the nearest key found out. Finally the key pressed is found out.

III. IMPLEMENTATION

Virtual keyboard use image processing algorithm in OpenCV to decease the processing time. It gives user a idea to connect with their laptop or PC using a virtual environment.

3.1. Hardware

The described components for hardware are used to make a proper prototype that could match the requirement of software design. Positions of the three main components are kept at a fixed height and angle such that the camera can capture the whole keyboard image. Height between projector and camera is kept to be 3cm which makes linear relationship between camera view and projector constant. Camera used wide angle lens for complete view of the keyboard layout at minimum height. As per the pre-defined keyboard key location stored in one dimensional array the height of both projector and camera is fixed. The only one laser plane generating component is kept at the lowest section touching the surface so to minimum distance between surface and laser plane. Laser keyboard generating diode is connected with current controlling circuit using potentiometer used to control the intensity of keyboard layout. Intensity of keyboard layout is independent of image processing algorithm. The whole hardware is powered with rechargeable 9v battery.

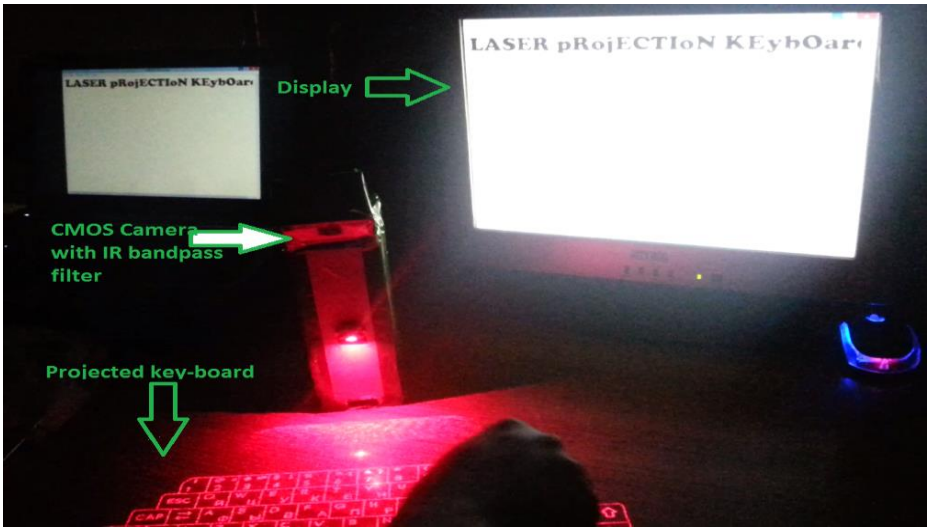

Figure 1. Working prototype

3.2. Algorithm

Design of algorithm is needed to be integrated with the hardware for proper working of the hardware. The Wi-Fi enabled camera is connected with laptop or PC for transmission of video frames. Rate of sending video frames is able to match with the transfer speed bandwidth allowing 30fps to be transferred easily. Software designed is completed after writing the code in openCV and compiling using g++ compiler generating object file, configuration file and application file. Application file generated is used to do the real time image processing using data send from Wi-Fi camera. With the start of application file an option pops up for selection of camera and then checking establishment of proper connection with camera. The processing of real time video frames [14] coming from wireless camera is continuously going through. If any key event is found the API informs the OS to print that corresponding key. The applications runs in the background to make user feel like actual keyboard.

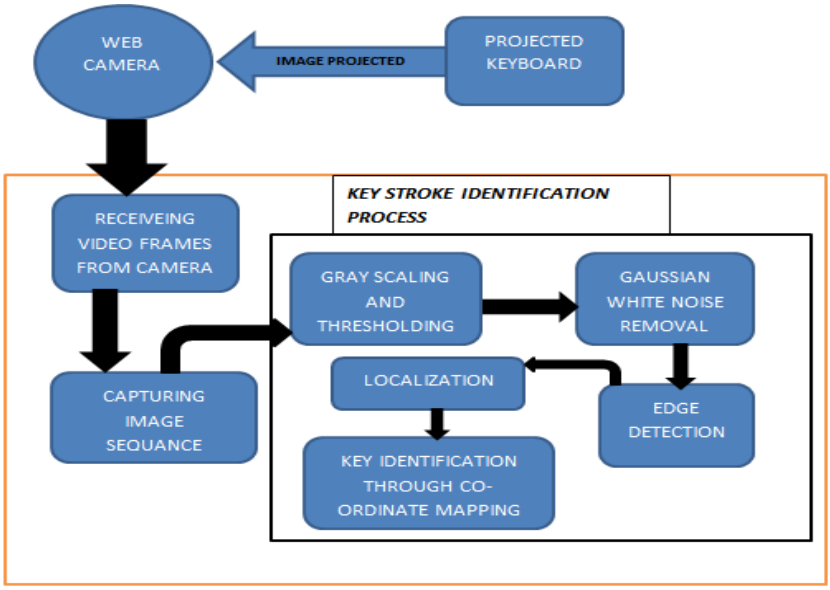

Figure 2. Key Stroke Identification process

3.3. Wireless Communication

Connection of Wi-Fi CMOS camera to the laptop or PC is done with simply using the Wi-Fi transmitter at 2.4GHz to establish a connection with the laptop or PC. The CMOS camera is used as transmitter and laptop or PC Wi-Fi connects to that network

3.4. Efficiency

The efficiency of algorithm is found out to be 90%. It is calculated using the test cases where 3 different paragraphs are written with their accuracy being calculated. At the same time key-stroke location mapping efficiency found out to be 80% giving correct result.

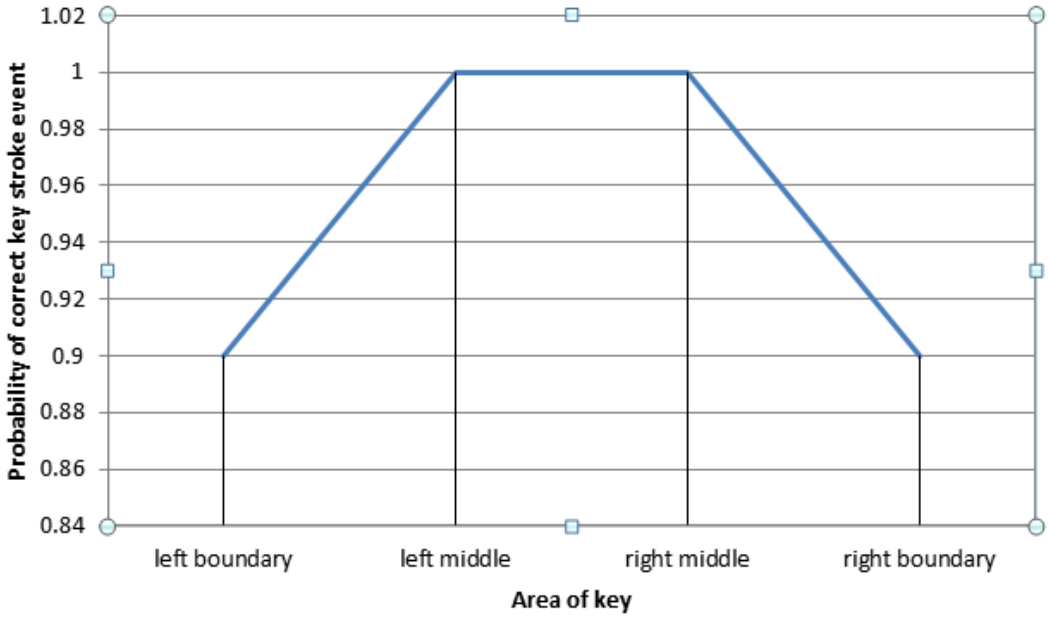

Figure 3. Probability of correct key stroke event v/s Area of Key

The probability of correct key-stroke event within a key area of projected keyboard layout is a slope down from value 1 to 0 as the finger stroke value shifts from centre to the boundary of key.

3.5. New Feature

The virtual keyboard has a feature of auto switch off mode. This feature allows the projected key-board layout to switch off the keyboard projector laser diode until the user finger comes near the keyboard region. An photodiode [15] is put just above the plane laser which continuously checks if the no signal is received for 300seconds then it switch off of the key-board layout projector to save power It switch on automatically by just hovering hand over the key-board layout.

3.6. ADVANTAGE

The most important advantage of this system is to make the system independent of on-board processing which uses most of the battery power as well as the independency of each module makes it easier for upgrade to new feature. The wireless feature makes it useful to work from a distant location with virtually controlling the laptop or PC.

IV. CONCLUSIONS

The virtual keyboard system with keyboard co-ordinate mapping has been implemented with minimum use of complex hardware structure and algorithm that provides a better result without much complexity. More gesture based feature can be added that will make it more close to the virtual device.

REFERENCES

[1]. Celluon keyboard (http://www.gizmag.com/celluon-epic-laser-keyboard-review/28342/) An Introduction to Virtualization by Amit http://www.kernelthread.com/publications/virtualization/
[2]. www.wikipedia.org (http://en.wikipedia.org/wiki/Laser_projection_keyboard) Yael Ben-Haim & Elad Tom-Tov "A Streaming Parallel Decision Tree Algorithm"IBM Haifa Research Lab, Journal of Machine Learning Research 11 (2010) 849-872
[3]. www.robopeak.com/blog/ Igor Brouk, Kamal Alameh "Design and Characterization of CMOS/SOI Image Sensors", IEEE TRANSACTIONS ON ELECTRON DEVICES, VOL. 54, NO. 3, MARCH 2007
[4]. www.dfrobot.com http://www.dfrobot.com/index.php?route=product/product&product_id=931#.U0rB4vTIuuI)
[5]. BI-CONCAVE LENS (BCC), http://www.lambda.cc/bi-concave-lens-bcc/
[6]. http://www.slideshare.net/priyalbhagat/laser-protection-virtual-keyboard
[7]. Kolsch, M. and Turk, M." Keyboards without Keyboards: A survey of Virtual Keyboards," n. pag. University of California, Nov. 05, 2003 (http://www.create.ucsb.edu/sims/PDFs/Koelsch_and_Turk_SIMS.pdf).
[8]. Lawrence Erlbaum Associates Inc, "Human Computer Interaction," pp 89-129,2002(http://www.almaden.ibm.com/u/zhai/papers/Zhai HunterSmithHCIGalley.pdf).
[9]. Alpern, M., "Projection Keyboards," Oct. 28, 2003 (http://www.alpern.org/weblog/stories/2003/01/09/projectionKeyboards.html).
[10]. Baxes, G. A. "Digital Image Processing – Principles and Applications, America, 1994.
[11]. Gonzalez, R. and Woods, R.,"Digital Image Processing,," India, 2002.
[12]. Wijewantha N. S.," VistaKey: A Keyboard Without A Keyboard – A Type Of Virtual Keyboard," Final year project thesis, Informatics Institute of Technology, Wellawatta, Sri Lanka, April 2004.
[13]. Hirsh, L., "Virtual Keyboard Replicates Real Typing," Oct. 23, 2003 (http://www.wirelessnewsfactor.com/perl/story/147 62.html).
[14]. Wrolstad, J., "Laser Device Projects Full-Size Keyboard for Handhelds," Oct. 28, 2003 (http://www.wirelessnewsfactor.com/perl/story/177 56.html).
[15]. Khar, A., "Virtual Typing," Oct. 28, 2003 (http://www.pcquest.com/content/technology/10303 0402.asp).
[16]. Aid Inc, "LightKey Visualize A Virtual Keyboard. One With No Moving Parts," Nov. 12, 2003(http://www.advancedinput.com/AIDpdfDownloads/AIDLightKey.pdf)

AUTHORS

Aman Mittal was born in 1992.He is pursuing bachelors in Electronics and Communication Engineering from Guru Gobind Singh Indraprastha University, New Delhi. His main research interests include Robotic systems, computer vision and System Integration. He has participated in several projects and currently working on a generic device.

Kunal Thakral was born in 1992. He is pursuing bachelors in Electronics and Communication Engineering from Guru Gobind Singh Indraprastha University,New Delhi. His main research interests include Robotic systems, micro-controller and Gesture control. He has participated in several projects and currently working on a generic device and UART.

Souvik Roy was born in 1992.He is pursuing bachelors in Electronics and Communication Engineering from Guru Gobind Singh Indraprastha University, New Delhi. His main research interests include Robotic systems, computer vision and machine learning. He has filled patent on new technique to save water during irrigation. He has implemented in several ideas into working prototype and currently working on freescale semiconductor's smart car coding competition using ARM microcontroller.

Ajay Kumar Singh was born in 1992.He is pursuing bachelors in Electronics and Communication Engineering from Guru Gobind Singh Indraprastha University, New Delhi. His main research interests include Robotic systems, computer vision and System Integration. His main research interests include Robotic systems, UAVs, computer vision, Embedded and System Integration. He has participated in several projects and currently working on a generic device.