

HARDWARE & SOFTWARE CO-SIMULATION OF EDGE DETECTION FOR VIDEO PROCESSING

¹Prof. Swati Shinde, ²Mayuri Gadhari, ³Nayan Gothal and ⁴Sonal Nikam

¹Assistant Professor, ²Under Graduate Student, ³Under Graduate Student and ⁴Under Graduate Student

Department of Electronics & Telecommunication Engineering
K. J. Somaiya Institute of Engineering and Information Technology
Mumbai, India

Abstract : In image edges are one of the most important features for image processing and computer vision applications. Edge detection is the classical studies since it is prerequisite thing prior to perform any image or video processing operation. Real time image processing applications required hardware implementation of Edge detection algorithms. In this paper, gradient based edge detection algorithms such as Sobel, Canny and Laplacian are implemented on Raspberry-pi Board. Using OpenCV libraries all these edge detection algorithms are designed in Python programming. The emerging market for image and video processing systems requires high-performance digital signal processing and low device cost for a volume application. The Raspberry Pi is a basic embedded system, small in size and a low cost a single-board computer used to reduce the complexity in terms of speed, area of systems in real time applications. This platform is mainly based on python programming and OpenCV libraries.

Index Terms-- Image and Video Capturing, Raspberry Pi, Camera Module, Python, OpenCV, Sobel, Canny and Laplacian Algorithm.

I. INTRODUCTION

The work is all about is a standalone device which is an independent computer which uses Raspberry-pi as its processor. The computer can also be used as regular computers with same features. Image processing is the algorithm and techniques used to manipulate and analyze images. Transformations can filter out an unwanted elements present in an image, alter colors or shapes to produce desirable properties, or extract information about the image and objects in an image. This image processing concepts are implemented in Raspberry pi and it is developed in the UK by the Raspberry Pi Foundation. Raspberry Pi 3 Model B+ has 1.4GHz 64-bit quad-core ARM Cortex-A53 CPU Broadcom processor. Python used as main programming language for Raspberry pi. OpenCV is an open source project an important part of the library as the implementation. So, the source codes for the tutorials are part of the library in OpenCV. Computer vision is a rapidly growing field, because as a result of cheaper and more capable cameras, partly because of less processing power, and partly because vision algorithms are starting to mature. OpenCV is playing a great role in the growth of computer vision by enabling thousands of people to do the productive work in vision. With focus of OpenCV on real-time vision, it helps students and professionals efficiently to implement projects with a computer vision and that was previously available only in a few mature research labs.

II. LITERATURE REVIEW

A lot of work done on edge detection of image to detect edge of an object. On the basis of edge detection algorithm we can improve quality of image for human Construe. Image processing used in various field such as in product industries, medical application, for digital space image detection from satellite, for vehicle detection, etc.

There are basically three methods to detect edges in the image or video:

1. First order derivative (Gradient) Method.

Example: i) Robert operators

ii) Prewitt operators

iii) Sobel operator

2. Second order derivative Method

Example: i) Laplacian

ii) Laplace of Gaussian

iii) Difference of Gaussian

3. Optimal edge detection Method

i) Canny Edge detection

In paper [1] represented how to implement an image processing algorithm applicable for Edge Detection system in a Python OpenCV using System Generator for still image, with a focus on achieving high performance, low value and short development time to come in market. The design of edge detection is demonstrate with help of Python OpenCV programming. Raspberry pi 3B+ board use to implement this design.

In paper [2] the different algorithms for edge detection are applied for input images and compared the result. This paper gives brief idea about the edge detection techniques which gives the different output and from that they concluded that canny gives a better result.

III. BASIC IMAGE PROCESSING

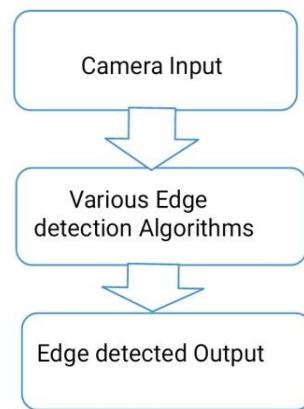


Figure 1: General Flow Diagram for edge detection process

Generally, any digital image processing system algorithm consists of three stages: (1) input image, (2) image processing (3) processed output. In the stage of input image is captured by a camera. Then it sent to a particular system to focus on a pixel of image which gives, its output as a processed image.

Image processing is a method to convert an image into digital form and perform operations on it, in order to get a processed image or to extract some useful information from image. It is a type of signal exemption in which input is image, like photographs or video frames and output may be image or characteristics associated with the image. Usually Image Processing system treats images as two dimensional signals while applying signal processing methods to them. Today it is among rapidly growing technologies, with its applications in various sectors. Image Processing develops core research area in engineering and computer science disciplines too. There are two types of methods used for Image Processing are Analog and Digital Image Processing. Analog techniques are also called visual techniques of image processing can used for the hard copies like photographs and printouts. Image processing uses various methods of interpretation while using these visual techniques. The image processing is not just limited to area that has to be studied but on intelligence of analyst. Association is the important part in image processing through visual techniques. So students and analysts apply a combination of personal knowledge and data to image processing. Digital Processing techniques help in manipulation of the images by using computers. As raw data from image sensors from satellite platform contains defects. To get over such defects, disadvantages and to get originality of information, it has to go through various stages of processing. There three general stages through all types of data have to undergo while using this technique are Pre- processing, enhancement and display, information extraction.

IV. SYSTEM HARDWARE

The Raspberry Pi board is the central module of the whole embedded image capturing and processing system as given in fig. 2. Its main parts include: main processing chip unit, memory card, power supply port, HDMI Out i.e. VGA display, Ethernet port, four USB ports, Memory slot, Camera serial interface, Display serial interface and 40 pin GPIO.

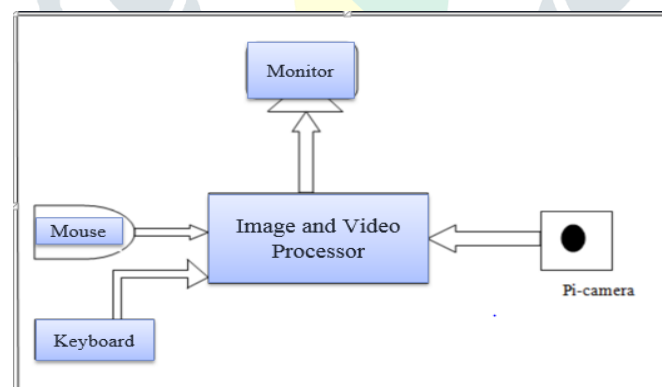


Figure 2: System Block Diagram

A. Raspberry Pi Model

The main signal processing chip [4] unit used in Raspberry Pi system is a Broadcom 2835 700MHz Chip in which CPU core is a 32 bit ARM1176JZF-S RISC processor designed by Advanced RISC Machines. This processing chip connects a camera module and display. The Raspberry Pi design does not include a built in hard disk or solid state drive, instead used SD card for booting and long term storage. This Raspberry Pi module has a Samsung class 4 micro SD card preloaded with the Raspberry Pi NOOBS (New out of Box Software) package, and a printed Micro SD card adapter.



Figure 3: Raspberry Pi 2 Board (Model B+)

B. Camera Interface

The camera module used here is Raspberry pi camera module as shown in the Fig. 4. The camera module plugs to the CSI connector on the Raspberry Pi. It's able to deliver clear 5MP resolution image, or 1080p HD video recording at 30fps. The camera module attached to Raspberry Pi by a 15 pin Ribbon Cable [6], to the dedicated 15 pin MIPI Camera Serial Interface (CSI), which was designed especially for interfacing to cameras. The CSI bus is capable of providing extremely high data rates, and it exclusively carries pixel data to the BCM2835 processor.



Figure 4: Raspberry Pi Camera Board

V. METHODOLOGY

For the proposed method the Raspberry pi board is the main controller. The latest version of Raspbian stretch lite is used on to the board. After installing the Operating System to the board connect all the necessary hardware components and turn on the power supply.

SOBEL EDGE DETECTION ALGORITHM

The Sobel operator is type of first order derivative edge detection operator. It computes the gradient of image intensity. At every point in the image the resultant gradient at the point is given by Sobel norms. The sobel operator uses two 3*3 kernel masks which is convolved with input image. There are only 0 and 90 degree convolution kernel used by sobel operator which changes the image vertically and horizontally respectively. The magnitude of gradient [5] at each point is find out by combining these two individual kernels. The gradient magnitude is given as follows:

$$|H| = \sqrt{Hx^2 + Hy^2} \dots\dots\dots (1)$$

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

Hx (Convolution kernel in x direction)

$$\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$

Hy (Convolution kernel in y direction)

The magnitude of gradient is given by:

$$|H| = |Hx| + |Hy| \dots\dots\dots (2)$$

This is much faster to compute. The advantage of sobel operator is its simple to calculate. Edge is detected with help of two convolution kernels that's reason it has low accuracy.

CANNY EDGE DETECTION ALGORITHM

The Canny edge detection is a technique to extract structural information obtained from various vision objects. It has been widely applied to various computer vision systems. Canny has found that the need of the application of edge detection on miscellaneous vision systems are relatively similar. It uses multi-stage algorithms to detect edges in the image. The Process of Canny edge detection algorithm can be broken down to following different steps:

1. Apply Gaussian filter so it smooth the image in order to remove the noise
2. Find the image intensity gradient function of the image.
3. Apply non-maximum suppression to avoid the spurious response to edge detection
4. Apply double threshold so we can determine potential edges
5. Track edge by hysteresis: by suppressing all the other edges that are weak and not connected to strong edges finalize the detection of edges.

LAPLACIAN EDGE DETECTION ALGORITHM

The laplacian edge detection operator is a second order differential operator. Original form as laplacian is a second derivative mask, it is very sensitive to noise. Thus if an image contains noise, the laplacian gives very large values and also damage the image in the process. Thus laplacian only is never used for edge detection. But, if some kind of noise filtering is done before the laplacian operation, better results can be obtained.

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix} \qquad \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix} \qquad \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

Taking 4 neighbours

Taking 8 neighbours

While applying Laplacian highlights small detail, it de-emphasizes smooth regions.

Solution: Add original image to repair background features.

$$g(x,y)=f(x,y)-\nabla^2f(x,y), \text{ negative filter center}$$

$$g(x,y)=f(x,y)+\nabla^2f(x,y), \text{ positive filter center}$$

Sharpening using Unsharp Masking: Suppress blurred part of image from the image itself to produce sharp image.

$$g(x,y)=f(x,y)-\bar{f}(x,y)$$

VI. RESULT

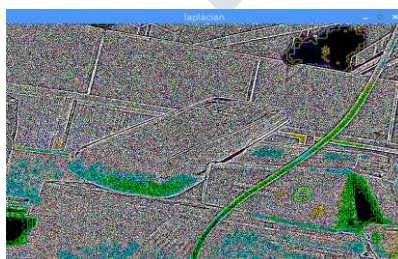
Comparative Analysis of Various Edge Detection Techniques

Edge detection is a technique in which sharp changes in image brightness level is detected. Thus the transition in image where brightness changes sharply is identified and gives the edge detected image as output. It consist of mathematical methods to extract set of curved that is line segment which separates brightness level called edges. There are various methods of edge detection.

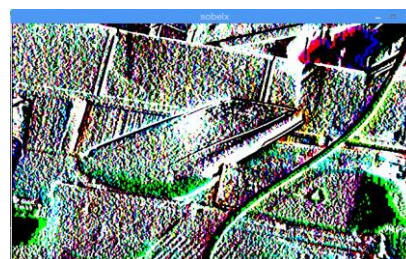
0 Laplacian operator is sensitive to noise, therefore the output image contains the noise elements and the edges are not sharper. Sobel operator is first order derivative gradient method. It uses two gradient masks which gives sobelx and sobely output. The coefficient mask are not fixed and they can be adjust as per the requirement. In all cases Canny gives sharper edge output and its effectiveness can be adjusted by using parameters.



(a)



(b)



(c)

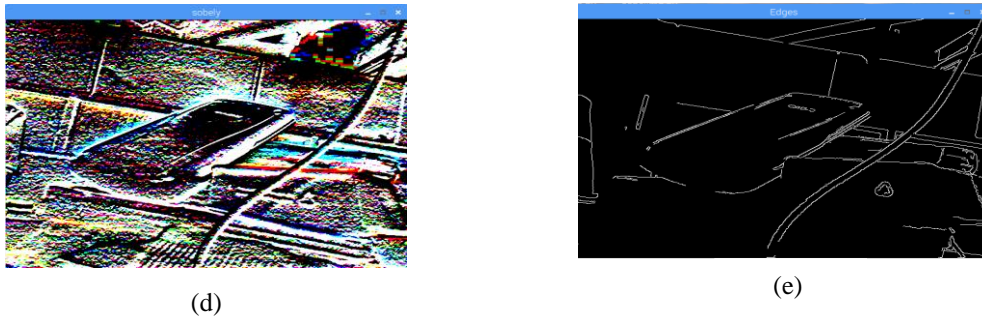


Fig 5: (a) Original image (b) Laplacian Operator (c) Sobel edge detection output for sobelx (d) Sobel edge detection output for sobely (e) canny edge detection output

VII. APPLICATION

Image processing have various applications which needs edge detection and there we can easily apply our proposed model of hardware software co-simulation technique such application are given below:

1. Biometrics application.
2. Edge detection of Digital aerial image.
3. Vehicles detection.
4. Detecting object in an image.
5. For machine vision also we can use it.

VIII. CONCLUSION

This paper represents the Comparative study and Analysis on Edge Detection Techniques. Real Time video edge detection achieved using Laplacian filter, canny and sobel edge detection on Raspberry pi board through OpenCV libraries and python programming. The comparison between the output of Laplacian filter, sobel edge detection and canny edge detection is carried out. From experimental results canny edge detection gives the better result for real time video edge detection. The proposed approach is applicable for Defective product detection in product industry using Image processing.

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