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Night Vision Motion Estimation: A Survey

Patel Ami M.[1], Assi. Prof. Swapna J Jadhav[2]

PG Student, Dept of Electronics and Communication, Sardar Vallabhbhai Patel Institute of Technology, Vasad, India [1]

Assistant Professor, Department of Electronics and Communication, Sardar Vallabhbhai Patel Institute of Technology, Vasad, India [2]

Abstract: Video Surveillance during night is important as far as security is concerned these days. The current technologies require RFIDs which are costly and hence the security domains in all become expensive. This paper describes the use of low cost single board computer Raspberry Pi which follows motion detection algorithm written in python as a default programming environment. It aims to present a review of various block matching algorithms used for night vision motion estimation. Developing a system which captures real time images and transmit it via a 3G Dongle to a Smart phone through e-mail. The algorithm for motion detection is being implemented on raspberry pi which enables live video streaming along with the human detection. The advantages and disadvantages of the algorithms are mentioned in this paper. The major goal of the paper is to provide a comprehensive reference source for the researchers involved in security.

Keywords: Video Surveillance, Raspberry Pi, Image thresholding, Motion detection, Block matching, Motion vector.

I. INTRODUCTION

Video Surveillance [12] refers to observation of real time video of a region from a remote area. IP and PTZ cameras are used for deliverance of real time video remotely. However their usage is restricted when cost matter is concerned. Raspberry Pi is the least expensive technology whose usage is being proposed in this paper as an alternative for video surveillance [6]. It is the cheapest and commercially available option when comparing with other alternatives. Paper presents a new dimension in the security domain by utilising this mini board. Here paper proposed a review of various methods of Block matching algorithm [14] which is used to estimate the motion.

In motion estimation process[14], firstly, a frame is partitioned into many non overlapping blocks with different block sizes according to the motion contents, secondly, the target block in the current frame is compared with the candidate blocks in the reference frame; under the constraint of cost function, we can obtain the best matched block by minimizing the cost function, and finally, the motion vector(MV), which represents the displacement between the current block and the best matched block, together with the residual signal, which is the pixel difference between the current block and the best matched block, are transported to the next process to be coded. Motion estimation is quite computationally intensive and can consume up to 80% of the computational power of the encoder if the full search (FS) is used by exhaustively evaluating all possible candidate blocks within the search window. Therefore, fast algorithms are highly desired to significantly speed up the process without sacrificing the distortion seriously. In this paper, the fast motion estimation algorithms which are Exhaustive Search (ES), Three Step Search (TSS), Diamond Search (DS), Four Step Search (4SS) and Adaptive Road Pattern Search (ARPS) are explained[7][8][10]**.** In this system various image processing techniques such as image filtering, image thresholding, image segmentation, contour fitting are used for making image better. The underlying supposition behind motion estimation is that the patterns corresponding to objects and background in a frame to form corresponding objects on the subsequent frame.

The paper presented here is organized as follows. Section 2 briefs about mini board Raspberry Pi. In Section 3 Related Research which contains Noise Filtering Methods, Image Segmentation, Image Thresholding Techniques, Morphological Operators, Motion Estimation, and Block Matching Algorithms.

II. HARDWARE DESCRIPTION

Raspberry Pi-An Introduction

Raspberry Pi: It is credit card sized computer, which can plug into any HDMI input device or RCA video input device and a keyboard is required for operation. Once it is initialized the HDMI and keyboard can then operate it by other means such as ssh for command line interface and VNC if graphical user interface is desired. The main technical specifications of the latest model of Raspberry Pi also known as Model B have the following key features:

- A 900 MHz quad-core ARM Cortex-A7 CPU
- 1 GB RAM
- 4 USB ports
- Full HDMI port
- Ethernet port
- Combined 3.5 audio jack and composite video
- Camera interface(CSI)
- Display Interface(DSI)
- Micro SD card slot
- Video core IV 3D graphics core

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Figure 1 Raspberry Pi 2 model B [1]

The Raspberry Pi runs Linux based operating systems and pycharm is an Integrated Development Environment (IDE) used for programming in python as it cross-platform working on Windows, Mac OS X and Linux which can run almost all programs . It provides code analysis, a graphical debugger, an integrated unit tester, integration with version control systems (VCSes), and supports web development [1] [2].

III. RELATED RESEARCH

A. Noise Filtering Methods

Noise is the unwanted variation and fluctuation in image which is captured by the camera. Noises in the images are arising during the image acquisition and transmission of data. There are various types of noise are present in image such as salt and pepper noise, Gaussian noise, gamma noise, Rayleigh noise and uniform noise. Due to the noise information in the image are lost so, it is necessary to filter the image. In this step, on captured image noise is present. Various noise filtering methods such as median filtering, mean filtering, Gaussian blur filtering, Min-Max filtering are used to remove the noise. Among all filtering methods median filtering provides better results but for real time, Gaussian blur filter gives better result [3].

B. Image Segmentation

Segmentation is used to differentiate the object and the background in an image.

- Intensity based Segmentation: Segments an image based on the intensity levels and is called as threshold based approach.
- Threshold based approach classifies an image into two classes: 1) Pixels belonging to certain range of intensity values.2) Rest of the pixels in the image.

C. Image Thresholding Techniques

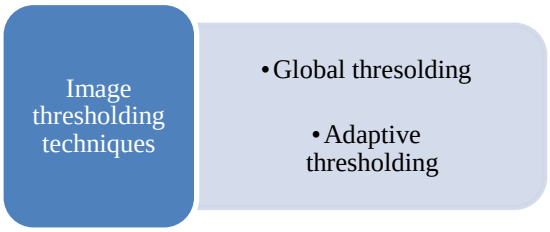

Figure 2 Reviewed methods for image thresholding [4]

Image Thresholding is the technique of image segmentation. In the Thresholding technique colour image or gray scale image is converted into the binary image. Image Thresholding separate the object from the background.

1. Global Thresholding

In global thresholding technique single threshold value is used for whole image.

$$g(x,y) = \begin{cases} 1 & i(x,y) \geq t \\ 0 & i(x,y) \leq t \end{cases}$$

Where g(x,y) =output image
i(x,y) = input image
t= threshold value

Global thresholding works better when the histogram of image is uniformly distributed. The disadvantage of the global thresholding technique is that it gives bad segmentation under varying light condition.

2. Adaptive Thresholding

Adaptive thresholding technique image is divided into the sub images. The thresholding value is depend on the neighborhood pixel properties. Separate thresholding value is used for all sub images. This algorithms works fine under the varying light condition and it provide better segmentation compare to the global thresholding technique.

D. Morphological Operators

Morphological operations are affecting the form, structure or shape of an object. Applied on binary images (black & white images – Images with only 2 colours: black and white).

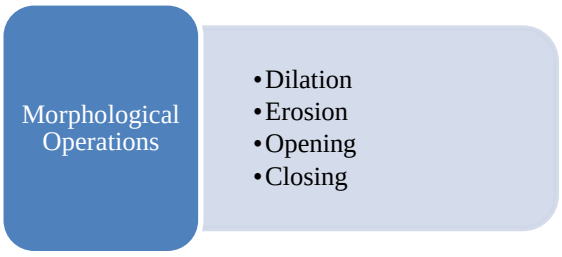

Figure 3 Morphological Operators [5]

- The two principal morphological operations are dilation and erosion.
- Dilation allows objects to expand, thus potentially filling in small holes and connecting disjoint objects.
- Erosion shrinks objects by etching away (eroding) their boundaries.
- These operations can be customized for an application by the proper selection of the structuring element, which determines exactly how the objects will be dilated or eroded.

Notation: black pixel: in gray scale values for a 8 bits/pixel indexed image its value will be 0
white pixel: in gray scale values for a 8 bits/pixel indexed image its value will be 255

- These two basic operations, dilation and erosion, can be combined into more complex sequences. The most

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useful of these for morphological filtering are called opening and closing.

- Opening consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element. In this case the structuring element is often called a probe, because it is probing the image looking for small objects to filter out of the image [5].

E. Motion Estimation

Motion estimation is a process of determining motion vectors that describe the transformation from 2D image to another; usually from adjacent frames in a video sequence. The motion vectors may relate to the whole image (global motion estimation) or specific parts, such as rectangular blocks, arbitrary shaped patches or even per pixel[8].

In video compression, a motion vector is the key element in the motion estimation process. It is used to represent a macro block in a picture based on the position of this macro block (or a similar one) in another picture, called the reference picture. Motion vector is a two-dimensional vector used for inter prediction that provides an offset from the coordinates in a reference picture.

Block Matching Algorithm:

In block matching [14] motion estimation process, there is a high correlation between each pixel and its surrounding in a frame. Therefore, it is not necessary to assign motion vector to each pixel. It is enough to identify one motion vector per a block of pixels.

In a typical frame work to block matching motion estimation, a frame is divided into blocks of n×n then, for the maximum motion displacement of P pixels per frame, the current block of pixels is matched against a corresponding block at the same coordinates but in the previous frame. The best match on the basis of a matching criterion yields the displacement.

The bigger value for n means that the number of total blocks which need to process in each frame are decreased and for this reason, it is clear that the computational complexity will reduce.

Matching Criteria

Block matching is a subset of image matching and can be consider from a view perspective. In many image processing tasks, sometimes it is essential to examine two images or two portions of images on a pixel by pixel basis. These two images or two image regions can be choose from a spatial image sequence.

The aim of the examination is to determine the similarity between the two images and two portions of images. The similarity measure or correlation measure is a key element in the matching process. On the other hand, instead of finding the maximum similarity, or correlation, an equivalent yet more computationally efficient way of block matching is to find the minimum dissimilarity, or matching error.

There are several types of matching criteria, such as the mean square error (MSE), and mean absolute difference (MAD) are illustrated below, which are used most of the time.

$$\mathrm{MSE} = \frac{1}{n^2}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}(C_{ij} - R_{ij})^2$$

$$\mathrm{MAD} = \frac{1}{n^2}\sum_{i=0}^{n-1}\sum_{j=0}^{n-1}\left|C_{ij} - R_{ij}\right|$$

Where n is the size of the macro block

C_{ij} and R_{ij} are the pixels being compared in current macro block and reference macro block, respectively

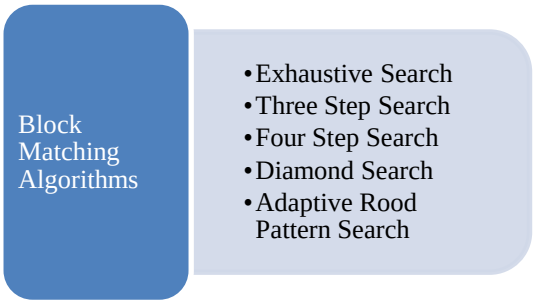

Figure 4 Block Matching Algorithms [8]

1. Exhaustive Search:

This algorithm, also known as Full Search, is the most computationally expensive block matching algorithm of all. This algorithm calculates the cost function at each possible location in the search window. As a result of which it finds the best possible match and gives the highest PSNR amongst any block matching algorithm. Fast block matching algorithms try to achieve the same PSNR doing as little computation as possible. The obvious disadvantage to ES is that the larger the search window gets the more computations it requires.

2. Three Step Search:

It gives a flat reduction in computation by a factor of 9. So that for p = 7, ES will compute cost for 225 macro blocks whereas TSS computes cost for 25 macro blocks. The idea behind TSS is that the error surface due to motion in every macro block is unimodal. A unimodal surface is a bowl shaped surface such that the weights generated by the cost function increase monotonically from the global minimum.

3. Four Step Search:

The 4SS algorithm utilizes a center-biased search pattern with nine checking points on a 5 x 5 window in the instead of a 9 x 9 window in the TSS. This algorithm helps in reducing the number of search points when compared to the TSS and hence is more robust. Based on this four-step search pattern, we can cover the whole 15 x 15 displacement window even only small search windows, 5 x 5 and 3 x 3, are used. This 4SS produce better performance than the TSS and it also possesses the regularity and simplicity of hardware-oriented features.

4. Diamond Search Algorithm:

The DS algorithm employs two search patterns. The first pattern, called Large Diamond Search Pattern (LDSP) comprises nine checking points from which eight points surround the center one to compose a diamond shape. The

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second pattern consisting of five checking points forms a small diamond shape, called Small Diamond Search Pattern (SDSP). This algorithm consistently performs well for the image sequence with wide range of motion content. It also outperforms the well-known TSS algorithm while reducing computation by 20%-25% approximately.

5. Adaptive Rood Pattern Search Algorithm:

This algorithm makes use of the fact that the general motion in a frame is usually coherent, i.e. if the macro blocks around the current macro block moved in a particular direction then there is a high probability that the current macro block will also have a similar motion vector. This algorithm uses the motion vector of the macro block to its immediate left to predict its own motion vector.

IV. CONCLUSION

This paper provides the overview of the various image processing techniques used. Web camera is used for the capturing the image. On the captured image noise filtering techniques are used. Among various filtering methods Gaussian blur filtering works best for real time applications. After the noise filtering image segmentation techniques are used. As compared to the global Thresholding technique adaptive Thresholding technique gives better segmentation under varying light condition. In this paper, an overview of some block matching motion estimation algorithms range from the very basic Full Search to the recent fast adaptive algorithms like Pattern Based Search in video. Full search motion estimation is not suited for real time applications because of its computational cost. Normally ME consumes more computational power of the encoder if the full search is used for evaluating all candidate blocks within the search window. As a consequence, the computation of video coding is greatly reduced with pattern based block motion estimation.

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