Motion Detection Using an Improvised Frame Difference Method

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Abstract: Motion detection is one of the main steps of video processing. Based on different factors one can consider any method as the most appropriate one. In this paper, we are going to present a versatile motion detection method, which is very efficient in increasing processing speed and occupying less memory. Initially, a video is fed as the input to the system. If motion is detected, only then frames will be taken and stored in a separate folder for carrying out further processing. If no motion is detected, then not a single frame will be taken by the system. This method will help in avoiding unnecessary storing of data, which does not serve any purpose.

Keywords: background subtraction, frame differencing, motion detection algorithm, optical flow, thresholding.

I. INTRODUCTION

Video processing has been emerging as a burning topic in the recent era. It has found its applications in various fields for surveillance and security purposes. Researchers and scholars are trying their utmost to contribute as much as they can towards developing methods and products for the safety and comfort of people. Human beings or any other animals use their eyesight to see the world around them and use their brains to analyze the objects and differentiate them. Computer vision prefers giving a similar capacity to a machine or computer. Understanding a human action from any video has gained much importance in the field of computer vision. Some of the most important usage of computer vision are counting people, medical imaging, security, and human computer interaction. In video imaging, many moving target detection algorithms are there which can be substantially classified into three kinds: frame difference, background subtraction and optical flow field [1]. In this work, an improvised frame difference method is proposed.

II. MOVING TARGET DETECTION ALGORITHMS

A. Frame Difference Method

Frame Difference is the method by which we can compare images by analyzing each pixel of the image. In this method, we feed an input video and then convert it into a sequence of frames. Each frame is read and then converted into gray image format. Then consecutive frames are read in a looping mode. The absolute difference between the two frames is termed as the difference image. Mathematically,

Difference image =|Current frame – previous frame|

An optimal threshold value is applied to the difference image and the status of motion is checked as follows–

If the difference image's pixel value is greater than or equal to threshold value, then it would be a foreground pixel (binary "1" will be assigned), then motion is detected, otherwise it would be a background pixel (binary "0" would be assigned), then no motion is detected.

Figure 1 Illustration Of the Frame Difference Method

B. Background Subtraction

Background subtraction is a basic technique to detect a moving object in a video sequence. In this method, as soon as we turn ON the camera the very first frame captured, is considered as the background frame. This frame is fixed and every time compared with the input frame. Practically, to detect a moving object using this method we consider two frames, namely Background frame and Current frame. As already mentioned, background frame is recorded as soon as the camera is installed and every frame is subtracted from the background frame. The resultant image is termed as the difference image (Diff_image). Then, applying optimal threshold value to the obtained difference image, we get the binary threshold for the image. If the pixel value of the difference image is greater than or equal to threshold, then it would be considered as a Foreground Pixel (Binary "1" is to be assigned for the foreground element). It will be considered as a Background Pixel if difference image is less than threshold (Binary "0" to be assigned for the background element), as in the equation below, thereby detecting a moving object.

Diff_image = | (Background frame) - (Current frame) |

In more technical terms, if we consider V (x, y, t) as a video sequence where t is the time dimension, x and y as the pixel location variables, then the easiest way to perform frame difference is to consider an image as background and consider the frames obtained at time t. It is then denoted by I(t) and compared with the background image denoted by B. In this case, using easy arithmetic estimation, we can do segmentation of the objects by using image subtraction method of computer vision. It means that for each pixels in I(t), considering the value of the pixel denoted by P[I(t)] and subtracting the values with the pixels having the closest similarity at the exact position on the background image denoted as P[B].

Mathematically, we can write it as:

$$P[F(t)] = P[I(t)] - P[B] \tag{1}$$

Figure 2 Mixture Of Gaussians

C. Optical Flow

The Optical flow or, optic flow is the example of noticeable motion of objects, work surfaces, and boundaries in a perceptible scene caused by the comparative motion between a spectator and a scene. The name optical flow is also used by roboticists, encircling related expertise from image processing controlling navigation including motion detection, segmentation of objects, focus to increase statistics, luminosity, motion rewarded encoding and stereo disparity dimension.

Let us consider a simple scene with some objects in motion. For video, we would consider a set of frames consecutively. For simplicity, here we will consider only two frames. The main objective of this technique is to find the motion field of the object moving. The actual motion field is in 3-dimension. Two assumptions are considered in this technique:

Assuming the evident intensity of objects in motion remains constant in between frames.

Assume the image brightness is continuous and differentiable.

Basically, optical flow can be widely categorized into dense optical flow and sparse optical flow. The difference between sparse optical flow and dense optical flow is that sparse flow only calculates the flow for certain specified pixels, while dense optical flow calculates the flow for all the pixels. This makes sparse algorithms often faster. In case of a large movement between the two images the algorithms sometimes cannot detect the movement. A solution for this, which both Lucas-Kanade and Gunnar Farneback use, are pyramids [3].

Optical flow constraints-

An object can shuffle positions from a small interval of time t1 to t2, while the reflectivity and lighting will remain same.

Mathematically, this can be shown by-

$$f(x+\Delta x, y+\Delta y, t+\Delta t) \approx f(x, y, t) \quad (2)$$

Where f(x, y, t) is the intensity of the image at position (x, y) at time "t", and Δx and Δy are the changes in position and Δt is the change in time. The first order Taylor expansion of the left term is:

$$f(x+\Delta x, y+\Delta y, t+\Delta t)$$
$$= f(x, y, t) + \frac{\partial f}{\partial x}\frac{\partial x}{\partial t}\Delta t + \frac{\partial f}{\partial y}\frac{\partial y}{\partial t}\Delta t + \frac{\partial f}{\partial t}\Delta t + \text{higher order terms}$$
$$= f(x, y, t) + (f_x u + f_y v + f_t)\,\Delta t \quad (3)$$

From equations (1) and (2), we get-

$(f_x u + f_y v + f_t)\,\Delta t = 0$, where, ft is the image difference between the two images.

There are many methods for calculating optical flow. For example, Lucas and Kanade employed a method which finds the flow vector using the constraints of a neighborhood around the pixel. Horn and Schunk made use of derivatives to estimate the initial constraint on the flow vector, and then solve for the orthogonal component by making use of a global method of reducing a smoothness constraint. These two methods have been briefly described underneath-

Horn and Schunk –

It was born in 1981. It is one of the classic methods of smooth optical flow. The main idea was to come up with an optical flow that minimizes an error. The first of the error was how much do we violate the brightness consistency constraint equation. Referring to equation 3, we get the constraint equation error term as-

$$E_c = \iint_{image} (f_x u + f_y v + f_t)^2 \, dxdy \quad (4)$$

As we have more number of constraints than equations, so we consider a smoothness error term-

$$E_s = \iint_{image} \{(u_x^2 + u_y^2) + (v_x^2 + v_y^2)\} \, dxdy \quad (5)$$

u_x is the derivative of u in the x-direction,

u_y is the derivative of u in the y-direction,

v_x is the derivative of v in the x-direction,
v_y is the derivative of v in the y-direction.
Then find (u, v) at each point of the image that minimizes:
$E = E_s + \lambda E_c$;
λ is the weighting factor. The more is the weighting factor; higher will be the satisfaction of the brightness consistency constraint. The smaller the weighting factor, the more the smoothing factor dominates.

Figure 3 Optical Flow Using Horn and Schunk: Arrows show direction of Motion

Lucas-Kanade-

Let us consider an image I(x, y). For smaller motion, the new image can be represented as:

H(x, y) = I(x+u, y+v); where, (u, v) represents the displacement of the pixel.

Solving this equation using Taylor series expansion, we obtain the Lucas-Kanade equation:

$$\begin{bmatrix} \sum IxIx & \sum IxIy \\ \sum IxIy & \sum IyIy \end{bmatrix} \begin{matrix} u \\ v \end{matrix} = -\begin{pmatrix} IxIt \\ IyIt \end{pmatrix}$$

Figure 4 Optical Flow using Lucas-Kanade: Arrows show the direction of Motion

Gunnar Farneback-

The Gunnar-Farneback method was originally introduced to obtain dense Optical Flow procedure results. The very first step will be to estimate each neighborhood of the two frames by quadratic polynomials. After that taking into consideration these quadratic polynomials, a new signal is created by a global displacement. Finally, this global displacement is estimated by tallying the coefficients in the yields of quadratic polynomials.

Figure 5 Optical Flow using Gunnar Farneback: Arrows show direction of motion

III. PROPOSED METHOD

- First of all, we input a video. Then, we apply frame difference.
- The video is converted into a sequence of frames. Each frame is read and then converted into gray image format.
- Absolute difference between two frames is calculated using the formula :

Diff_image = |current frame – previous frame|;

If Diff_image = 1(binary), then it is a foreground pixel. If Diff_image = 0(binary), then it is a background pixel and motion is detected.

If motion is detected (i.e , Diff_image = 0), then the frame is stored for further processing. If no motion is detected(i.e, Diff_image = 1), then the respective frame is not stored. This is an effective method since it requires less memory as it processes only those frames which are stored only after motion has been detected.

Figure 6 Fig. 6. Output from the proposed Algorithm

In the above output, due to slight motion (movement of hair due to fan), 'MOTION DETECTED' text has appeared (which has already been coded) and frames are taken by the system for further processing. The image given below is the difference image corresponding to the above result-

Figure 7 Threshold Image when motion was detected

Figure 8 Output when no motion is detected

Fig. 8. Shows the result of motion detection when there is actually no motion, hence no text has appeared and not a single frame will be stored by the system.

IV. CONCLUSION

Our proposed algorithm reduces processor memory complexity in video processing system.

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