Інформаційні технології

UDC 004.932

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EFFICIENCY TEST FOR GRADIENT OPERATOR AND LAPLACIAN OPERATOR IN KALMAN FILTER'S TV TRACKING VIA CHI-SQUARE TEST

The spread of electronics to variety of applications created a growing need in systems that track moving objects detected by real time TV imaging. Many applications of such systems exist, for example, computer vision, biomedical imaging, and gunfire control systems. The objective of TV tracking is to determine the position in the image plane of an independent moving object (the target) detected by a TV camera and in to "track" that object throughout its motion. Results over of comparative tests of different methods of edges determination are brought between characters on a television image. Tests showed that the Laplacian operator is more effective, than gradient operator at the use of him in the Kalman filter.

Keywords: *gradient operator, Laplacian operator, Kalman filter*

Introduction

The general layout of a real time TV tracking system may have the form shown in Fig. 1. The platform signals, represented by the azimuth and elevation angles of the camera position with respect to a certain reference, are the alignment errors due to the difference between the line of sight (LOS) and the camera optical axis.

These signals are fed into the stepper motor of the platform to guide the camera in the direction of the moving target until the optical axis coincides with the LOS such that the target remains centered in the (FOV). Finally, the TV monitor is used for supervision enabling an operator to establish a visual contact of the tracking process.

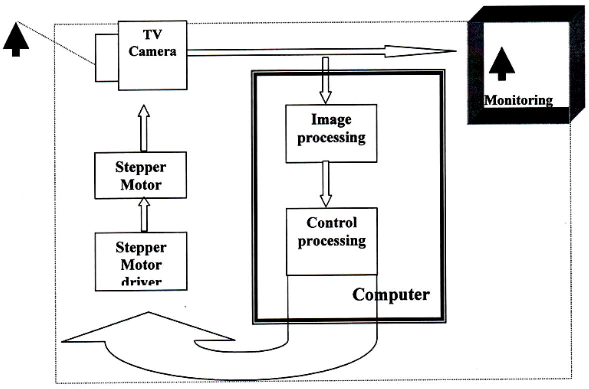

Fig. 1. The general layout of a real time TV tracking system

TV tracking systems are considered useful in short-range applications because of the ability to visualize the target [1]. Their high resolution capability and However, atmospheric conditions and complicated background environments affect their performance, where it becomes difficult to identify targets under such circumstances. Most of the techniques are based on pattern recognition, which uses statistical and structural methods. Such an approach is based on the hypothesis that features of objects from different classes lie in easily separable regions of the multidimensional feature space, while features from the same class cluster together [2]. Passive nature make more effective in situation where transmitted signals are subjected to noise jamming and other countermeasure techniques, as opposed to other systems.

Image Segmentation

To describe target motion in a time-varying sequence of images, a complicated image is converted into a simpler form by a process known segmentation. This is the process that subdivides an image into its constituent parts or objects [3].

Edge Detection

An edge is the boundary between two regions with relatively distinct gray-level properties. In the following discussion, the assumption is that the regions in question are sufficiently homogeneous so that the transition between two regions can be determined on the basis gray-level discontinuities alone. When this assumption is not valid, basically the idea underlying most edge-detection techniques is the computation of a local derivative operator. Fig.2 Illustrates this concept.

Fig. 2-a shows an image of a light stripe on a dark background, the gray-level derivatives of the profile. Note from the profile that an edge (Transition from dark to light) is modeled as a smooth, rather than as an abrupt change of gray-level.This model reflects the fact that edges in digital images are generally slightly blurred as a result of sampling. Fig.2-a shows that the first derivative (1) of the gray level profile is positive at the leading edge of a transition, negative at the trailing edge, and, as expected, zeros in areas of constant gray level.

$$G = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \partial f/\partial x \\ \partial f/\partial y \end{bmatrix}, \tag{1}$$

$$\nabla f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2}. \tag{2}$$

The second derivative (2) is positive for that part of the transition associated with the dark side of the edge, negative for that part of the transition associated with the light side of the edge, and zero in areas of constant gray-level. Hence the magnitude of the first derivative can be used to detect the presence of an edge in an image, and the sign of the second derivative can be used to determine whether an edge pixel lies on the dark or light side of an edge. Note that the second derivative has a zero crossing at the mid-point of a transition a gray-level. Zero crossings provide as a powerful approach for locating edges in an image. Although the discussion so far has been limited to a 1-D horizontal profile, a similar argument applies to an edge of any orientation in an image.

We simply define a profile perpendicular to the edge direction at any desired point and in interpret the results as in the preceding discussion . The first derivative at any point in an image is obtained by using the magnitude of the Gradient at that point. The second derivative is similarly obtained by using the Laplacian.

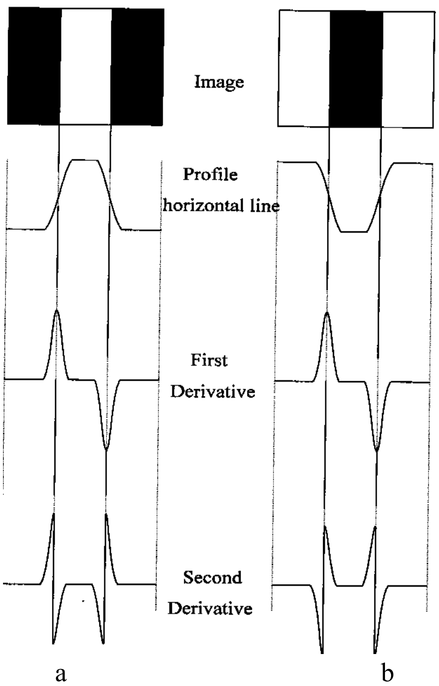

Fig. 2. Local derivative operator

Gradient operator

The gradient of an image f(x,y) at location (x,y) is the vector. It is well known form vector analysis that the gradient vector points in the direction of maximum rate of change of f at (x, y). In edge detection an important quantity is the magnitude of this vector, generally referred to simply as the gradient and denoted of equation (3).

$$\nabla f = \mathrm{mag}(G) = \left| G_x^2 + G_y^2 \right|^{1/2}, \tag{3}$$

$$\nabla f \approx |G_x| + |G_y|, \tag{4}$$

$$a(x,y) = \tan^{-1}\left(G_x / G_y\right), \tag{5}$$

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3), \tag{6}$$

$$G_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7). \tag{7}$$

This quantity equals the maximum rate of increase of f(x, y) per unit distance in the direction of G. Common practice is to approximate the gradient with absolute value, equation (4), which is much simpler to implement, particularly with dedicated hardware. The direction of the gradient vector also is an important quantity.

Let a(x,y) represents the direction angle of the vector at (x,y). Then from vector analysis, Where the angle is measured with respect to the x axis. From equations (4) and (5) show that computation of the gradient of an image is based on obtaining the partial derivatives $\partial f/\partial x$ and $\partial f/\partial y$ at every pixel location. Derivatives may be implemented in digital form in several ways. However, the Sobel [3] operators have the advantage of providing both a differencing and a smoothing effect.

Because derivatives enhance noise, the smoothing effect is a particularly attractive feature of the Sobel operators derivatives based on the Sobel operator masks. Where, as before, z's are the gray levels of the pixels overlapped by the mask at any location in an image. Computation of the gradient at the location of the center of the masks then utilizes Fig. 3, giving one value of the gradient.

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

-1	-2	-1
0	0	0
1	2	1

-1	0	1
-2	0	2
-1	0	1

Fig. 3. The Sobel operator masks

To get the next value, the masks are moved to the next pixel location and the procedure is repeated. Thus, after procedure has been completed for all possible locations, the result is a gradient image of the same size as the original image. As usual, mask operations on the border of an image are implemented by using the appropriate partial neighborhoods.

Laplacian operator

The Laplacian of a 2-D function *f(x,y)* is a second order derivative defined as in the case of the gradient, equation (2), may be implemented in digital form in various ways.

$$\nabla^2 f = 4z_5 - (z_2 + z_4 + z_6 + z_8). \tag{8}$$

For 3x3 region, the form most frequently uncounted in practice The basic requirement in defining the digital Laplacian is that the coefficient associated with the center pixel be positive and the coefficients associated with the outer pixels be negative. Because the Laplacian is a derivative, the sum of the coefficients has to be zero. Hence the response is zero whenever the point in question and it is neighbors have the same value. Although, as in indicated earlier, the Laplacian responds to transition in intensity, it is seldom used in practice for edge detection for several reasons, As a second-order derivative, the Laplacian typically is an unacceptably sensitive to noise. Moreover, the Laplacian produces double edges and is enable to detect edge direction. For these reasons, the Laplacian usually plays the secondary role of the detector for establishing whether a pixel is on the dark or light side of an edge [3]. A more general use of the Laplacian is in finding the location of edges using it's zero-crossings properly (see Fig.4). This concept is based on convolving an image with the Laplacian of a 2-D Gaussian function of the form equation

$$h(x,y) = \exp\left(-\left(x^2+y^2\right)\Big/\left(2\sigma^2\right)\right), \qquad (9)$$

where σ^2 is the standard deviation [4]. Let $r^2 = x^2 + y^2$. Then from equation (10) the Laplacian is Fig. 5-a shows as a cross section of this circularly symmetric function. (Note the smoothness of the function). This shape is the model upon which equation (10) and the mask in Fig. 4 is based.

$$\nabla h = \left(\left(r^2-\sigma^2\right)\Big/\sigma^2\right)\exp\left(-r^2\Big/\left(2\sigma^2\right)\right). \qquad (10)$$

When viewed in 3-D perspective with the vertical axis corresponding to intensity, equation (10) has a classical form. It can have shape. The average value of the Laplacian operator is zero. The same is true of the Laplacian image obtained by convolving this operator with a given image [3].

Tracking results testing

Results of the tracking stage are store in profiles, to test them in this section the Chi-Square test is used to examine these output results, to get the error in this output apply the equation (11)

$$E_i = (o_i - e_i)^2 / e_i\,, \qquad (11)$$

where E_i is an error, o_i is an actual x_c, and e_i is an estimated x_c. for i^{th} scene.

Testing the edge detection results

It is first starts with an output of Kalman filter's tracking, which used Gradient operator centroid, to get the error in this output apply the equation (11). The Chi-Square value with (y = 30) degree of freedom and confidence interval (a =0.05), is (X^2 = 13.2500) and the tabled value of the Chi-Square is (χ^2=43.773), while $X^2 < \chi^2$ that is mean an estimated values is accepted.

Secondly the output of Kalman filter's tracking, which is used Laplacian operator's centroid and to get the error in this output apply equation (11). The Chi-Square value with (y = 30) degree of freedom and confidence interval (a =0.05), is (X^2 = 11.9528) and the tabled value of the Chi-Square is (χ^2 =43.773), while $X^2 < \chi^2$ that is mean an estimated values is accepted.

Conclusion

The results of two operators showed that X^2 for an operator Laplacian less than X^2 for the operator of Gradient, which avaricious operator Laplacian, more effective for the Kalman filter.

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Надійшла до редколегії 25.06.2015

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ЕФЕКТИВНІСТЬ ТЕСТУ ДЛЯ ОПЕРАТОРА ГРАДІЄНТА І ОПЕРАТОРА ЛАПЛАСА В ТЕЛЕВІЗІЙНОМУ ВІДСТЕЖЕННІ ФІЛЬТРА КАЛМАНА ЧЕРЕЗ ТЕСТУВАННЯ КСІ-КВАДРАТ

Аль-Джанаби Акіл Бахп Тархан, Л.А. Шувалова

Метою ТВ трекінгу є визначення положення в площині зображення незалежного рухомого об'єкта (цілі) при виявленні сліду, отриманого від об'єкта на протязі його руху. Наведені результати порівняльних випробувань різних методів визначення контурів об'єктів від фону зображення на екрані телевізора. Випробування показали, що оператор Лапласа є більш ефективним, ніж градієнтний оператор, коли він використовується у фільтр Калмана.

Ключові слова: *оператор градієнта, оператор Лапласа, фільтр Кальмана.*

ЭФФЕКТИВНОСТЬ ТЕСТА ДЛЯ ОПЕРАТОРА ГРАДИЕНТА И ОПЕРАТОРА ЛАПЛАСА В ТЕЛЕВИЗИОННОМ ОТСЛЕЖИВАНИИ ФИЛЬТРА КАЛМАНА ЧЕРЕЗ ТЕСТИРОВАНИЕ КСИ-КВАДРАТ

Аль-Джанаби Акил Бахп Тархан, Л.А. Шувалова

Целью ТВ трекинга является определения положения в плоскости изображения независимого движущегося объекта (мишени) при обнаружении следа, полученного от объекта на протяжении его движения. Приведены результаты сравнительных испытаний различных методов определения контуров объектов из фона на телевизионном изображении. Испытания показали, что оператор Лапласа более эффективен, чем оператор градиента при использовании его в фильтре Кальмана.

Ключевые слова: *оператор градиента, оператор Лапласа, фильтр Кальмана.*