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Determination of Object Location by Analyzing the Image Blur

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Abstract

Problems of automation of individual modules and entire segments of integrated monitoring and surveillance systems for the transport infrastructure in areas with large concentrations of people and everywhere where it necessary to recognize certain objectives and their parameters are very relevant and timely. In this paper, the idea of determining the parameters of an object by its blurring is developed. It is assumed that a blurring is different for different colors, which decomposes a single image. It is offered as separate element of the study to consider the object boundary, which determines the sharpness. Placing objects according to the flat reference scale of blur changes, it can determine the distance from the observer to each of them.

Keywords: image blur, object parameters, distance to the object

1 Introduction

Nowadays an increasing role in various information systems, automated control systems and integrated monitoring systems begin to play algorithms and modules of the determining of static and non-static object's various characteristics: its distance from the observer, speed, position coordinates in space [1-3], etc. To solve such problems active systems that emit electromagnetic waves of certain frequencies: radars, infrared sources, motion sensors are often used, but overall complication algorithms for registration, processing, transmission and storage of data, developers are forced to simplify some elements of technical support to reduce the final cost of the system and to simplify the procedure for obtaining some basic information on the investigated (recognizable) object [4-10]. One of the directions of such simplifications is the refusal to use, in addition to cameras, coupled with them detection devices (radar, various sensors). If this is an attempt to create such algorithms that would help to get all necessary information about the object only by its image or series of images [11-13].

To obtain the images using conventional video detectors, video cameras, which can generate a graphic image of a high-definition view of all available on a photo or video colors. The main characteristics of the objects included in the image, are the coordinates and velocity at any given time. Form of an object of interest in the works of most authors is constant, although this fact depends significantly on the path of movement of the object and the angle of its playback by the video detector. Therefore, in general, cannot be considered permanent form of the object, as well as its geometrical dimensions, so in this paper, along with the image of the object the concept the image of its boundary on which can be easier to identify such image parameters as sharpness and blur of individual fragments is introduced. The feature of the proposed algorithms and techniques is the transition from the image parameters to the parameters of the moving object.

There are several approaches to determine the characteristics of objects that can move: stereo vision, i.e. the presence of several photo detectors; definition for a given motion blur of a video camera; focus adjustment of the detector; definition of the blur for different colors within the image of the object. Each method has its advantages and disadvantages associated with the technical and programmatic possibilities of the implementation of individual procedures.

In this paper we develop a method of determining the parameters of static or moving object, it is based on an algorithm to process one or a series of images obtained with a certain time interval. Firstly, the degree of blur in several ways, in order to evaluate their accuracy and to verify algorithm is measured, then distance to the object, depending on its degree of blur is calibrated and the calibration can be performed both in manual and automatic mode, according to the methods of processing and object type.

2 Problem Statement

From a variety of colors in the image to identify main colors that would cover the entire available spectrum is offered. Since each of them corresponds to a specific wavelength, and, respectively, the frequency which varies according to the subject's movement Doppler equation:

$$w=w_0(1\pm u/c) \quad (1)$$

where w_0 - frequency with which the source emits waves; c - velocity of wave propagation in the environment; u - speed of the receiver relative to the environment.

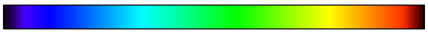

Fig. 1: Light spectrum.

Light spectrum is decomposed into the following colors, which correspond to different wavelengths: 380 - 470 nm - purple, blue; 500 - 560 nm – green; 560 - 590 nm – yellow, orange; 590 - 760 nm - red (Fig. 1).

For "null" (minimum) blur to take blur of pixels of green "middle" color is offered, with blue and red colors blur will be closer to the maximum (Fig.2).

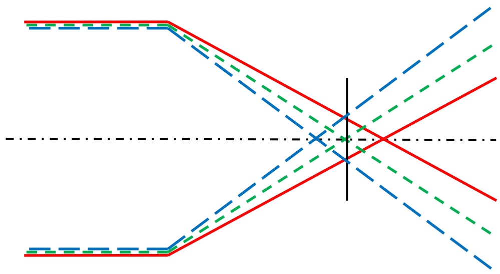

Fig. 2: Focusing RGB-rays.

The eye sees the image as a set of three colors: red, green and blue (Fig.3).

3 Object Distance Determination

Distance to the object represented in the image is proposed to determine, taking into account the blur diameter, the diameter and focal length of the lens for medium and extreme colors of the considered range, green and red, respectively, when receiving images in normal lighting conditions.

In the general case, without using of a difference of blur diameters for different colors, the distance from the detector to the object is provided, if the distance to the object in focus is known, and will be determined by the following equation:

$$d = \frac{Dpf}{(D+\sigma)f - \sigma \cdot p}, \tag{2}$$

where d - the distance from the detector to the object, f - focal length, p - the distance to the object located at the focal point, D - diameter of the lens, σ - diameter of the spot blur (it is considered that the point blur occurs equally in all directions).

Boundaries of the blur depend on the number of aperture f / D of the used camera: the higher the aperture, the less light reaches the camera's sensor and the area of a circle varies as the square of its radius [1]. To the upper limit of the blur did not go to infinity long-focus lenses should be used.

Blur softens noise on those fragments of the figure, in which there are abrupt changes of color, i.e. softens color transitions by averaging the values of sharp boundaries with neighboring pixels.

To find the accuracy of determining the distance to an object by its blurring it need to know the value of the diffraction blur of the entire image, which depends on the pixel size on this camera. Calculation of the difference of colors can eliminate the impact of general blurring of the resulting technical reasons (quality of the camera or weather conditions).

In general, for two colors (Fig. 3) will be:

$$\frac{1}{d}+\frac{1}{V1}=\frac{1}{F1} \tag{3}$$

$$\frac{1}{d}+\frac{1}{V2}=\frac{1}{F2} \tag{4}$$

$$\frac{s_2}{D}=\frac{V2-R}{V2} \tag{5}$$

$$\frac{s_1}{D}=\frac{V1-R}{V1} \tag{6}$$

where σ_1 and σ_2 - blur diameters of the first and second colors, respectively; F1 and F2 - focal length of a lens used for the first and second colors, respectively, D - diameter of the camera lens.

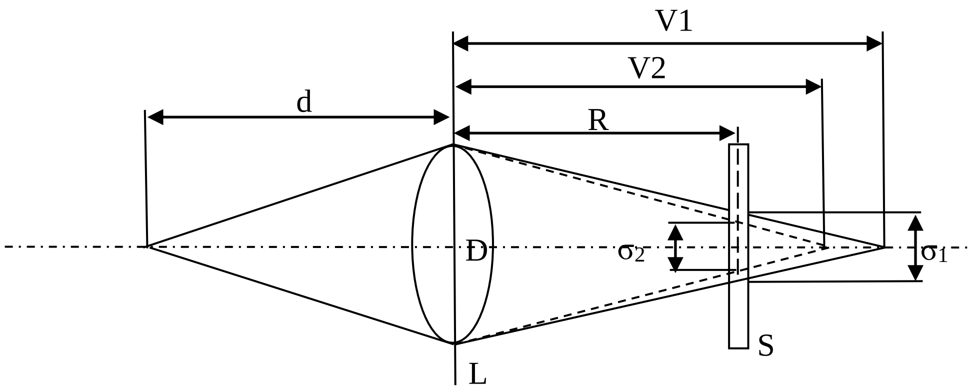

Fig. 3. The general case for any two colors.

For a moving object the decomposition of the image blur by color is shown in Fig. 4.

Solving this system of equations (3, 4, 5, 6) we obtain an expression for determining the distance to the selected object:

$$d=\frac{(\sigma_1-\sigma_2)\cdot F1\cdot F2}{(\sigma_1\cdot F1-\sigma_2\cdot F2)+(F2-F1)\cdot D}, \tag{7}$$

For red and green colors (Fig. 5) and the fact that green blur as zero, the expression for determining the distance from (7) to the selected object will look like:

$$d = \frac{\sigma_r \cdot Fr \cdot Fg}{(\sigma_r \cdot Fr + (Fg - F \cdot) r}, \tag{8}$$

where σ_r - blur diameter of the object for red color, Fr and Fg - focal length lens of the camera for red and green colors, respectively, D - diameter of the lens of the camera.

Fig. 4. Decomposition of an image on RGB-colors.

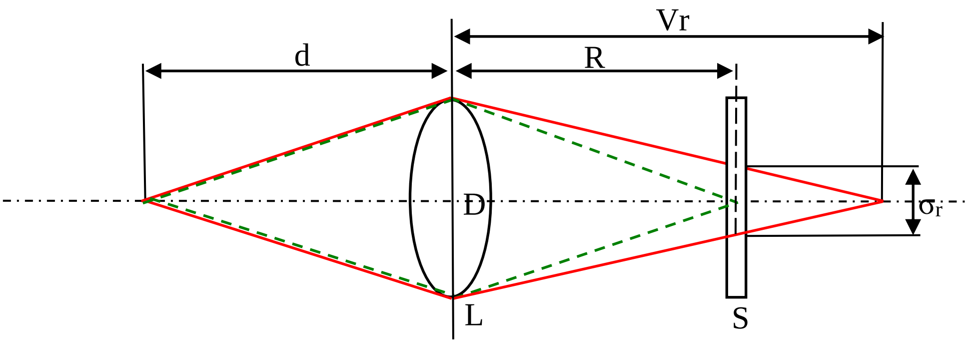

Fig. 5. Focusing green, and red colors.

Focal lengths of the used lens for the different colors can be found by experience: for example, Nagata found experimentally focal lengths eye "jumping" spiders for the red and green colors [2].

The main problem is finding of image blur estimation.

Object boundaries blur diameter in mm [3] is equal to:

$$\sigma_r = \Delta x_r \cdot Sx, \tag{9}$$

where Δx_r – the blur diameter of the object, measured in pixels, Sx - pixel size of CCD camera used [4].

Blur usually take as Gaussian distribution or uniform distribution [5]. There are several ways to calculate the blur estimation. The most popular are: the method proposed J.H. Elder and S.W. Zucker, and the method proposed by H. Hu and G. de Haan.

In the method proposed by Elder and Zucker [6], boundaries of blurring detect technically with a scaling of the local area and reliable scale are used to calculate correctly the boundaries suitable for evaluation of the blur. Center of the boundary is the point where the gradient is the largest. We find this point, using a controllable Gaussian filter of the first derivative, and this signal in the direction of the first derivative reaches its maximum where its derivative is zero. To find the size of the blur, we can take the distance between the highest and lowest gradients of the first derivative. To reduce noise thresholds on the amplitude of the first and the second derivative with values equal to standard deviations of Gaussian filter derivative are applied. The process is repeated several times with different values for Gaussian filters of derivatives because our images often have multiple meanings of blur. Thus, the size of the blur is calculated when there is a motion in the direction along the boundary of the first derivative of the gradient, while the first derivative becomes equal to zero. Blurring parameter [7] may be represented in graphical form, depending on the constituent color, i.e. on the wavelength. It can also plot the dependence between the blur and boundaries of color transition of the object, which is an independent element of the study, after which the resulting points describing the blurring of different colors can be built according to a certain the blur law [8] and determine the distance to an object on the proposed "reference" curve.

In approach of H. Hu и G. de Haan [9], they used twice the blur of the signal that will determine with known Gaussian kernels σ_a and σ_b to determine the local blur σ of the signal. For this signal the convolution with a Gaussian kernel with different standard deviations σ_a and σ_b, which leads to two signals $b_a(x)$ and $b_b(x)$, is used. To make the blur is independent from the amplitude and the offset ratio r(x) is calculated:

$$r(x)=(b(x)-b_a(x))/(b_a(x)-b_b(x)) \tag{10}$$

The ratio of the difference reaches its maximum when the difference between b(x) function and reblurred function is big. It will happen at the points where the signal amplitude changes significantly, i.e. points, where the blur had the greatest influence. In this local signal at a point where r(x) reaches the maximum, will be defined by σ of the entire region. As it happens, because we assume that the local spot is the same for this area. Therefore, we will apply the filter with the maximum specified window, and we obtain $r_{max}(x)$. If $\sigma a \cdot \sigma b > \sigma$, then, using the values of σ_a, σ_b and $r_{max}(x)$ we can rewrite the equation for our evaluation of the blur σ:

$$s \approx s_a s_b/((s_b-s_a)r_{max}(x)+s_b) \tag{11}$$

The failure of the condition $\sigma a \cdot \sigma b > \sigma$ leads to an incorrect estimate of blur σ [10].

The perfect boundary corresponds to a modified Heaviside function, which shows the presence of an object abruptly (Fig. 6).

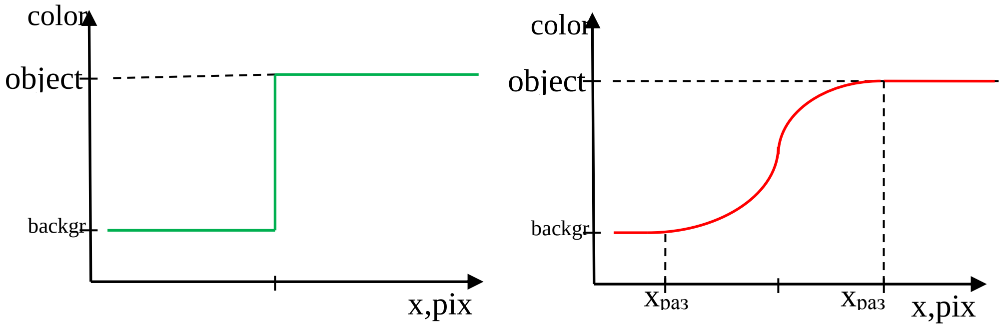

Fig. 6. An ideal edge and washed with Gaussian distribution of the border.

In this connection, it is sufficient to say that in the real world is not practically observed, and on the microlevel there is always a boundary layer whose thickness depends on the purity of the object of surface treatment and the conditions of reflection and refraction of light waves on the interfaces. For the simulation of object boundaries in real conditions to use a Gaussian distribution with a double convex-concave and an inflection point (point of the equality to zero of the second derivative of the color function on the coordinate) is proposed [11, 12]; depending on the definition, the width of the interval between two horizontal tangents will vary in various ranges [13]. Presenting this value in the form of a flat scale, you can calculate the distance from the observer to the object. The proposed scale has reference points for objects of a certain color and a certain distance to these points.

4 Conclusion

The developed method of definition the distance to the object can be used for determining of their parameters using active and passive measurements and algorithms for predicting their behavior and following 3D modeling of objects. The proposed in this paper method, after additional testing will be integrated into a developed complex system of video monitoring, including control blocks, recognition and identification, tracking of selected targets, as well as determining of the parameters of their status and movement, which should allow to reduce the influence of a operator on processes of production, transmission, processing and storage of information which is difficult to formalization.

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