DETECTION OF MOVING OBJECTS IN VIDEO SEQUENCES

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Computer vision systems are increasingly used in various fields of human activity. Among the various methods of digital image processing and video sequences, approaches focused on the detection and analysis of moving objects are important. With the rapid growth of number of unmanned aerial vehicles (drones) belonging to the consumer segment, as well as the development and use of unmanned aerial vehicles (UAVs) related to military equipment, it is very important to detect UAVs and record the violations of the perimeter of the No Drone Areas [1].

Given the fact that nowadays, even drones of the consumer segment are may be used for illegal and criminal acts, which include: entry into the private territory of residential buildings for the purpose of illegal collection of videos and photos and intrusion into the private life of residents; illegal transfer of goods across the state border or perimeters of objects that have a special status and are under protection; conducting real-time intelligence etc[1].

Among the various methods of moving object detection we can highlight the following: optical flux method [2]; method of background subtraction [3]; statistical method.

Statistical methods are based on the method of subtracting of the background. This method is used to remove regions of change (an area of an image with a moving object) from a stationary background.

Background subtraction detection methods are often used as a basis for further analysis of the area of the image in which motion is detected. Among the methods of forming the background of the image, which is considered that does not contain objects of interest, is to analyze individual frames of the video sequence, obtained at certain intervals, and thus the background can be evaluated as follows [4]:

$$I_{BG}(n,m) = \min\left(I_1(n,m), I_2(n,m), ..., I_k(n,m)\right), \qquad (1)$$

where $I_{BG}(n,m)$ — estimated background of the analyzed video sequence; n, m — value of row and column indices of the pixels in background image; $n=1,...,N$, $m=1,...,M$, where N, M — number of rows and columns in the frame of video sequence or still digital image; $I_t(n,m)$ — frames of video sequence that are obtained in different moments of time, $t=1,...,k$, where k — number of such frames; min() — function that determines the smallest value of appropriate pixels among images $I_t(n,m)$ and obtained values are assigned to appropriate pixels of background image $I_{BG}(n,m)$.

Another variant of determining the background, in contrast to (1), may involve finding the maximum values of the corresponding pixels among the frames presented for analysis [4]:

$$I_{BG}(n,m)=\max\left(I_1(n,m),I_2(n,m),...,I_k(n,m)\right), \qquad (2)$$

where $\max()$ — function that determines the largest value of appropriate pixels among images $I_t(n,m)$, $t=1,...,k$, and obtained values are assigned to appropriate pixels of background image $I_{BG}(n,m)$.

The disadvantage of approaches (1) and (2) in the estimation of the background may be the negative impact of pixels that are distorted by impulse noise, as well as frames that are overexposed or underexposed. Thus, the obtained background estimate may not correspond to the true values. Median filtering of individual frames of video sequences or a set of still images that are used for background analysis can be conducted to suppress impulse noise.

Another approach that allows to perform background estimation involves averaging individual frames:

$$I_{BG}(n,m)=\left(I_1(n,m)+I_2(n,m)+...+I_k(n,m)\right)/k, \qquad (3)$$

where k — the number of frames of the video sequence.

Some disadvantage of method (3) is that all frames have the same effect on the formation of the resulting background. This expression can be used when the lighting conditions and settings of the recording equipment remain unchanged.

Otherwise, a different approach can be used for better adaptation to changing environmental conditions [5]:

$$I_{BG}^{i}(n,m)=\rho I_{BG}^{i-1}(n,m)+(1-\rho)I_i(n,m), \qquad (4)$$

where $I_{BG}^{i}(n,m)$ — current estimation of background; $I_i(n,m)$ — current frame of the video sequence or still image that is used for background updating; i — number of current frame or still image that is used for background updating, $i=1...L$; L — amount of frames or still images that should be used for background estimation; ρ — coefficient that describes the influence of estimated background before the current frame $I_i(n,m)$ is obtained, $\rho=0,...,1$; $I_{BG}^{0}(n,m)=I_0(n,m)$ — where $I_0(n,m)$ is a frame or still image at the beginning of the process of background estimation.

After the background has been estimated, it is possible to search the regions where the moving object are present. For this purpose the difference of pixels of background image and pixels of the analyzed image is calculated[6]:

$$I_D(n,m)=\left|I(n,m)-I_{BG}(n,m)\right|, \qquad (5)$$

where $I_D(n,m)$ is a difference image; $I(n,m)$ — frame of video sequence or still digital image that contains the scene for analysis; $I_{BG}(n,m)$ — image of a background, that may be computed using i.e. expression (1)–(4).

Localized area in which a moving object is observed, should be analyzed to determine which class of objects the detected object is referred to. Correlation analysis may be used for such purposes. It is necessary to have a set of test images of moving objects of different classes, which can potentially be displayed in the analyzing scene. Another approach involves the use of neural networks as well as a large database of moving objects of different classes which can be registered in a video sequence or in a sequence of still images [7]. These approaches involve the use of separate methods and algorithms that allow, with a certain probability of correct detection to determine whether a moving object belongs to the appropriate class of object.

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Анотація

Розглянуто сфери застосування та перелік задач, в яких виявлення рухомих об’єктів на зображеннях та відео послідовностях може мати важливе практичне значення. Описані підходи до оцінки фону та використання різнецевого методу для виявлення областей, в яких відбувається рух об’єктів. Наведені подальші варіанти аналізу областей зображення, в яких були локалізовані рухомі об’єкти.

Ключові слова: відеопослідовність, виявлення рухомих об’єктів, оцінка фону.

Abstract

Areas of application and a list of tasks in which the detection of moving objects in images and video sequences can be of a practical importance are considered. Approaches for estimation of the background and using the difference method to identify areas with moving objects are described. Further stages of analysis of areas with moving objects in the image or video sequence are presented.

Keywords: video sequence, moving objects detection, background estimation.