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Sequential Boolean Background Estimation and Phasor Based Objects Segmentation

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1 Introduction

Object to background segmentation is the basic image processing and analysis step in many tasks: feature selection and extraction, detection, tracking, region of interest for neural network training, classification, etology (Urbanova et al. [2020]). For the behavior analysis, for example of swarms, herds, flocks, shoals, or crowds, the segmentation is carried out on the frames or images from video or time lapse photography, respectively. Segmentation, in this case, requires distinction of the moving objects from the actual background. Therefore, it is useful to generates the estimated background image for automatic segmentation. To evaluate the differences between estimated background and given image/frame, and fulfill the segmentation, metric based on phasor analyssis is adopted.

2 Boolean Background Generation

Computationaly simple and efficient method for bacground estimation was proposed by Teknomo and Fernandez [2009]. The algorithm uses three randomly chosen video frames, with the assumption of background partial occurrence in two of them. Iteratively, all video frames are used and parts of background from different images will merge together. The boolean algebra is performed as

$$\vee(\wedge(\veebar(f1, f2), f3), \wedge(f1, f2)). \tag{1}$$

While the Teknomo algorithm is giving valuable and quick results, unfortunately, it is a post-processing method, since the generating iteration is dependent on the randomness of the frames. However, with the semi-real-time evaluation, sequential analysis is necessary. This could be reached by very small framerate or not using each consecutive frame for the generator, to avoid artifacts of slowly moving objects. Simply, we need a kind of a keyframe, where only such keyframes are used in iterations and they are statistically distinct. Theoretically, no change should follows the Poisson distribution with noise fluctuations. If the difference between two frames exists, the distribution of differences will stop follow the Poisson process. Comparison of measured and theoretical histogram via Pearson's chi-squared test (Chráska [2006]) serves as thresholding for keyframe selection. Application of such adoption helps the boolean background generator convergence.

3 Phasor analysis

In order to minimize the intensity changes, given e.g. by shadows, whole analysis is performed in the chromatic color, where each color channel is weighted by the sum of all channels

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and only color information is represented. Urban [2017] The estimated background is slightly smoothed as a result of its generation. To avoid small differences artifacts, the current image is blurred by smallest possible Gaussian window. The estimated background image is then compared with the actual blurred frame, each pixel independently. The original differences, expressed in RGB 3D orthonormal color space are transformed to phasor, a rotating vector. The amplitude of the phasor is given by the Pythagoras formula as Euclidian distance between background and investigated pixels in RGB space. The triangle consist of three sides, background positional vector, given positional vector, and the amplitude vector. The positional vectors forms an angle, which gives the phasor phase. The common estimation of the phase expects that the triangle has one right angle (Kaba and Temeltas [2022]). In this work, we are presenting the approach using Cagnoli's formula of tangens for general triangle. Therefore, the phasor represents the amplitude and phase of the current image from the estimated background. For the final segmentation is used classical thresholding of between class variance Urban [2017].

Obrázek 1: Example of phase image of the fish shoal.

Poděkování

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