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Guided filter and convolutional network based tracking for infrared dim moving target

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Abstract: The dim moving target usually submerges in strong noise, and its motion observability is debased by numerous false alarms for low signal-to-noise ratio. A tracking algorithm that integrates the Guided Image Filter(GIF) and the Convolutional neural network(CNN) into the particle filter framework is presented to cope with the uncertainty of dim targets. First, the initial target template is treated as a guidance to filter incoming templates depending on similarities between the guidance and candidate templates. The GIF algorithm utilizes the structure in the guidance and performs as an edge-preserving smoothing operator. Therefore, the guidance helps to preserve the detail of valuable templates and makes inaccurate ones blurry, alleviating the tracking deviation effectively. Besides, the two-layer CNN method is adopted to obtain a powerful appearance representation. Subsequently, a Bayesian classifier is trained with these discriminative yet strong features. Moreover, an adaptive learning factor is introduced to prevent the update of classifier's parameters when a target undergoes sever background. At last, classifier responses of particles are utilized to generate particle importance weights and a re-sample procedure preserves samples according to the weight. In the predication stage, a 2-order transition model considers the target velocity to estimate current position. Experimental results demonstrate that the presented algorithm outperforms several relative algorithms in the accuracy.

Keywords: Infrared dim target tracking; Guided image filter; Convolutional network; Particle filter; Bayesian classifier.

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1 Introduction

The infrared target tracking has been widely used in military and civilian. The main task is to estimate the target location in the next frame. When the distance between the optical system and a moving target is large, the target in the imaging plane only contains only several pixels and has low Signal-to-Noise Ratio(SNR). With strong radiation, dim moving targets usually submerge in cluttered backgrounds, which is the crucial challenge. Besides, the motion state of a small target can be random and uncertain when it moves fast. Therefore, the accurate detection and tracking of a dim target is considered as a difficult work[1-15].

In general, infrared dim target tracking algorithms can be divided into two categories. One is based on the image filtering[4-11] and another is based on the target modeling and matching[12-15]. The first approach establishes an ideal motion model and then detects the target by filtering algorithms, such as temporal-spatial fusion filter[4], Moving Pipeline Filter(MPF)[5], Correlation Filter(CF)[6,7] and Particle Filter(PF)[8-11]. In CF-based algorithm[6], the frequency response of a filter bank was varied in each frame accordingly with local statistics of the observed signal. Afterwards, the target was detected in the restored frame by analyzing the correlation intensity planes obtained at the output of the filter bank. However, tracking deviation is frequent as the estimation of the dynamic background is inaccurate. In [10], Wang et.al. utilized Markov chain and Monte Carlo methods to approximate the solution of sequential target's state estimation. The particle filtering is useful for nonlinear motion. Nevertheless, it is computationally intensive, and also faces convergence problems over complex backgrounds. In addition, Li et al. presented a particle filter-based tracking algorithm to copy with the uncertainty of the dim moving target tracking[11]. The discriminative over-complete dictionary was utilized to enlarge the difference between the target