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Infrared dim-small target tracking via singular value decomposition and improved kernelized correlation filter

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Abstract: Infrared small target tracking plays an important role in applications including military reconnaissance, early warning and terminal guidance. In this paper, an effective algorithm based on the Singular Value Decomposition (SVD) and the improved Kernelized Correlation Filter (KCF) is presented for infrared small target tracking. Firstly, the super performance of the SVD-based algorithm is that it takes advantage of the target's global information and obtains a background estimation of an infrared image. A dim target is enhanced by subtracting the corresponding estimated background with update from the original image. Secondly, the KCF algorithm is combined with Gaussian Curvature Filter (GCF) to eliminate the excursion problem. The GCF technology is adopted to preserve the edge and eliminate the noise of the base sample in the KCF algorithm, helping to calculate the classifier parameter for a small target. At last, the target position is estimated with a response map, which is obtained via the kernelized classifier. Experimental results demonstrate that the presented algorithm performs favorably in terms of efficiency and accuracy, compared with several state-of-the-art algorithms.

Keywords: Target tracking; Infrared dim target; Image enhancement; Correlation filter; Curvature Filter.

1. Introduction

The infrared target tracking has been widely used in military and civilian. Similar to visual tracking, the key step of infrared target tracking is to constantly estimate the target position in infrared sequences. When a target is far away from the infrared system, the dim target with only a few pixels easily submerges in the cluttered background with strong radiation. Generally, the performance of real-time and accuracy is the crucial challenge for infrared dim target tracking as the target moves fast [1-5]. Besides, the edge of cloud around a target can lead to tracking migration. Therefore, the accurate detection and tracking of a dim target are considered as a difficult work.

Several researchers have made contributions to the infrared dim target detection and tracking [3-9], such as Template Matching Tracking (TMT) algorithm [3,4], Mean Shift (MS) algorithm [5,6], Temporal Spatial Fusion Filtering (TSFF) algorithm [7], and Particle Filter (PF) algorithm [8,9], et al.. Specifically, the TMT algorithm completed matching between frames using the gray feature. The TSFF algorithm processed the background suppression with the top-hat filter in the spatial domain. Meanwhile, it took advantage of an improved frame difference method to enhance the target. Besides, the MS algorithm represented infrared target appearances by kernel weighted gray histogram and utilized the mean shift procedure to identify the most likely position of the target in the next frame. To improve the performance of these tracking algorithms, Liu et al. presented a tracking framework based on the template matching combined with the Kalman Filter (KF) [10]. Such framework used the projection coefficients of PCA as templates and measured the matching degree by using nonlinear correlation coefficients. However, the tracking migration is frequent as the background clutter is sever. Li et al. combined an adaptive KF with mean shift [11]. The center of the object predicted by KF was utilized as the initial value of the MS algorithm. The searching result of MS was fed back as the measurement of