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A false-alarm aware methodology to develop robust and efficient multi-scale infrared small target detection algorithm

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Abstract

False alarm rate and detection rate are still two contradictory metrics for infrared small target detection in an infrared search and track system (IRST), despite the development of new detection algorithms. In certain circumstances, not detecting true targets is more tolerable than detecting false items as true targets. Hence, considering background clutter and detector noise as the sources of the false alarm in an IRST system, in this paper, a false alarm aware methodology is presented to reduce false alarm rate while the detection rate remains undegraded. To this end, advantages and disadvantages of each detection algorithm are investigated and the sources of the false alarms are determined. Two target detection algorithms having independent false alarm sources are chosen in a way that the disadvantages of the one algorithm can be compensated by the advantages of the other one. In this work, multi-scale average absolute gray difference (AAGD) and Laplacian of point spread function (LoPSF) are utilized as the cornerstones of the desired algorithm of the proposed methodology. After presenting a conceptual model for the desired algorithm, it is implemented through the most straightforward mechanism. The desired algorithm, effectively suppresses background clutter and eliminates detector noise. Also, since the input images are processed through just four different scales, the desired algorithm has good capability for real-time implementation. Simulation results in term of signal to clutter ratio and background suppression factor on real and simulated images prove the effectiveness and the performance of the proposed methodology. Since the desired algorithm was developed based on independent false alarm sources, our proposed methodology is expandable to any pair of detection algorithms which have different false alarm sources.

Keywords: False alarm aware development, average absolute gray difference, point spread function, multi-scale analysis, infrared target detection

1. Introduction

Nowadays, infrared imaging is used in a wide range of applications such as medicine, remote sensing, communications, climatology, astronomy, security and surveillance. Many of these applications get involved in the target detection scope. Among all the different target detection research fields, small infrared target detection faces specific difficulties. Since the incoming threat should be detected as away as possible from the searcher system, the resulting corresponding image of the small infrared target on the image plane is a dim and small spot. Detecting such a dim, small object faces difficulties as [1]:

- When the target is very far from the infrared imaging system (the pointwise target), the radiated infrared ray loses the majority of its energy. In this case, the desired signal level is very weak. On the other hand, the infrared imaging system generates different types of noise. Due to these two reasons, the signal to noise ratio (SNR) for the pointwise target is very low [2].
- In case of a small target, since the thermal fields of the atmosphere absorb and scatter infrared radiation, there is no sharp edge to distinguish the target area from the background clutter [3].
- Aerial clutters (birds and cloud edges) and naval clutter (sun glint) have similar specifications to the small infrared targets. In some scenarios, infrared images include heavy clutter and a complicated background which increases false alarm probability [4].
- Real-time processing of high resolution infrared images (the line-scan search and track system (IRST) or the high frame-rate focal plane array (FPA)) is another bottleneck in the small infrared target detection field [5].

Detector noise and background clutter are the sources of the false alarms in an IRST system which also degrade the detection ability of the system. The overall performance of the infrared target detection system is evaluated via false alarm and detection rate. In the infrared target detection terminology, these two metrics are closely related to background suppression factor (BSF) and signal to clutter ratio (SCR) which are defined as [6]:

$$SCR = \frac{f_T - f_b}{\sigma_b}, \tag{1}$$

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