Target Detection in Infrared Images Using Block-Based Approach

S. Rajkumar and P.V.S.S.R. Chandra Mouli

Abstract A novel and simple method for identification of targets in infrared (IR) images is proposed in this chapter. The input image is divided into blocks of fixed size. The saliency map is extracted block-wise in three different ways. In the first approach, the entropy of each block is compared with the global entropy of the image. In the second approach, the energy of each block is compared with the global energy of the image. In the third approach, combined entropy and energy are used. Experimental results show that the combined approach of entropy and energy detects the targets accurately compared to the other two methods. The subjective results show the efficacy of the proposed approach. The objective evaluation measures show the high detection rate and low false alarm rate.

Keywords Small target detection • Infrared imagery • Entropy-based approach • Energy-based approach

1 Introduction

The advent of IR imaging technology finds mammoth applications in defense and military problems. Target detection is the first and the foremost application of defense over the IR imagery. Even though the target detection in general is a classical and old problem, in the IR domain, it is still challenging. Human vision is limited to a small portion in the electromagnetic spectrum in the form of visible light. The infrared radiation is invisible to the human eye but can sense the heat-emitting objects at any time. Infrared imaging is mainly useful for military- and civilian-related application purposes. Military application includes surveillance, homing and tracking, target acquisition, and night vision, while nonmilitary

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application includes remote temperature sensing, thermal efficiency analysis, weather forecasting, spectroscopy, and environmental monitoring [1].

Infrared images play an important role in military and civil fields for small target detection since 1910 because targets have a low signal-to-noise ratio (SNR) [2–4]. Unlike visible cameras, IR images capture only the heat emitted from objects. The quality of these objects degrades due to sensor noise and other clutter noises. In view of these reasons, the target recognition in IR images is very difficult. Since the target recognition in IR images is difficult, it is required to detect the targets first for target localization.

Target detection in IR images is challenging and has profound applications in defense-related areas. The surveillance aircrafts equipped with IR sensors capture the scenes in field from faraway distances, since the targets in IR images are far away from imaging equipment and hence usually very dim and embedded in clutter background [5, 6]. Shaik and Iftekharuddin [7] have contributed much in the IR imaging domain. They explored the frequency domain correlation and Bayesian probabilistic techniques for the automatic target detection.

Small target detection using two-dimensional least mean square (TDLMS) [8] is a general adaptive filter algorithm applied to infrared small target detection. In this chapter, a new TDLMS filter structure is defined based on neighborhood analysis. Sungho Kim et al. [9] proposed a novel human visual system (HVS) contrast mechanism-based detecting algorithm, which is capable of increasing target intensity as well as suppressing background clutter and noise. In [10], an improved algorithm based on HVS for infrared small target detection in an image with complicated background is discussed. Targets under sea-sky background are detected using entropy and empirical mode decomposition in [11]. Fractal-based methods are used in [12] for target detection. A new concept called self-information map is introduced by Deng et al. in [13] which is integrated with adaptive thresholding for small target detection. Recently, the saliency-based work is progressing for target detection in IR images. Saliency extraction became an important step in the segmentation of images and in object recognition. Visual attention analysis and saliency extraction are applied in [14, 15]. Zhao et al. [16] proposed a real-time automatic target detection using saliency extraction and morphological theory. Local frequency-tuned-based saliency extraction method is proposed in this chapter. The potential targets are obtained by comparing the saliency extracted with adaptive thresholding map. Noise is suppressed as the post-processing step to remove any impulse present. In this chapter, an adaptive target detection method is proposed using block processing of IR image. The proposed method is a modified version of [16]. The subjective and objective evaluation shows that the proposed method detects the objects better than the existing methods.

The rest of this chapter is organized as follows. The proposed methodology is introduced in Sect. 2. Experimental results are presented in Sect. 3. In Sect. 4, performance analysis of the results is done by comparing with existing methods. Finally, Sect. 5 concludes the work.

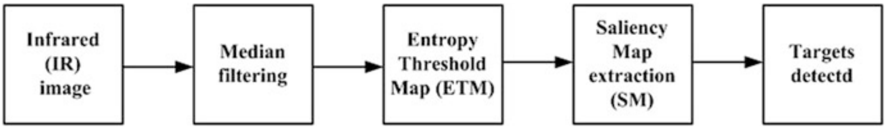


Fig. 1 Block diagram of the proposed method

2 Proposed Methodology

In this section, the proposed methodology is discussed in detail. The block diagram of the proposed method is given in Fig. 1. The IR image is captured from IR sensors from far-off distance and noise is inevitable. To remove the noise, median filtering is applied so that the image is blurred.

2.1 Saliency Map Extraction

The median-filtered image is used to extract the saliency map. To do this, block processing of the image is employed. The image is divided into blocks with necessary zero padding. After a series of experiments, the size of each block is fixed as 15×15 for which the detection rate is good. The lesser the block size, the smaller the probability of detection. Similarly, the higher the block size, the higher the probability of false alarm rate.

2.1.1 Entropy-Based Saliency Extraction

The entropy of the median-filtered image is calculated and compared with the local entropy of each block. The salience map is defined as

if (lent > gent) image_block = 1; else image_block = 0; end

where *lent* is the local entropy of the image _ block of size 15×15 and *gent* is the global entropy of the image. The analogy is that if the local entropy exceeds the global entropy, the probability that the block contains the heat-emitting object, i.e., target, is high. The saliency map thus obtained is a binary image where each white block represents the target and the rest is merged with the background.

2.1.2 Energy-Based Saliency Extraction

Instead of entropy, the energy of the median-filtered image is used to extract the saliency map. The energy-based salience map is defined as

if (leng > geng) image_block = 1; else image_block = 0; end

Table 1 OSU Thermal Pedestrian Database details

Collection #	No. of images
1	31
2	28
3	23
4	18
5	23
6	18
7	22
8	24
9	73
10	24

where *leng* is the local energy of the image _ block of size 15×15 and *geng* is the global energy of the image.

2.1.3 Entropy- and Energy-Based Saliency Extraction

In this approach, both entropy and energy together are used to extract the saliency map. The saliency map thus obtained is defined as

if ((lent > gent) & (leng > geng)) image_block = 1; else image_block = 0; end

3 Experimental Results

The proposed method is implemented over the OTCBVS infrared image database [17]. The results presented in this chapter are from the OSU Thermal Pedestrian Database. It contains 10 different collections of images. The total number of images in this collection is 284 in which 155 pedestrians (targets) are available. The details of each collection are given in Table 1.

The original image and the corresponding saliency map obtained are shown in Fig. 2. In Fig. 2, the first column represents the original image, the second column represents the saliency map obtained, and the third column represents the labelled map. The labelled map is generated for objective evaluation. The number of connected components is determined from the saliency map. Using the number of connected components, each component is labelled and assigned a unique color for discrimination. From the saliency map, the location and position of targets are determined and superimposed on the border of the target detected over the input image. The results are shown in Fig. 3.

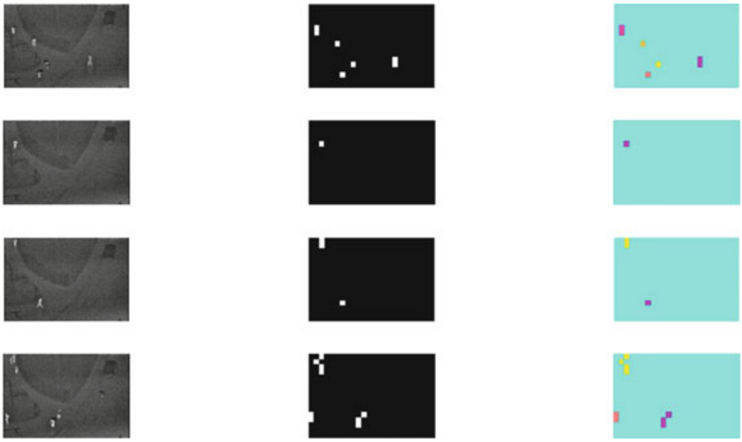


Fig. 2 Saliency map and labelled map obtained for the original IR image

4 Performance Analysis

The results obtained are statistically evaluated using the measures *PD* (detection rate) and *PFA* (false alarm rate). These are defined in Eqs. 1 and 2, respectively:

$$PD = \frac{\text{No.of true targets detected}}{\text{Total no.of targets}} \times 100\% \tag{1}$$

$$PFA = \frac{\text{No.of false targets detected}}{\text{Total no.of targets}} \times 100\% \tag{2}$$

The plots in Fig. 4 show the plot of mean detection rate and mean false alarm rate. From Fig. 4, the combination of entropy- and energy-based saliency map has higher detection rate and lower false alarm rate.

5 Conclusion

A set of three approaches are proposed for target detection in IR images. The proposed approaches are trivial but due to block processing of images help in higher detection rate and lower alarm rate. The combination of entropy and energy parameters led to an aggregate of around 96 %. It is planned to improve the work towards 100 % detection rate. To do that, a robust saliency map is planned by extracting robust features other than entropy and energy as future work.

Fig. 3 Saliency map and labelled map obtained for the original IR image

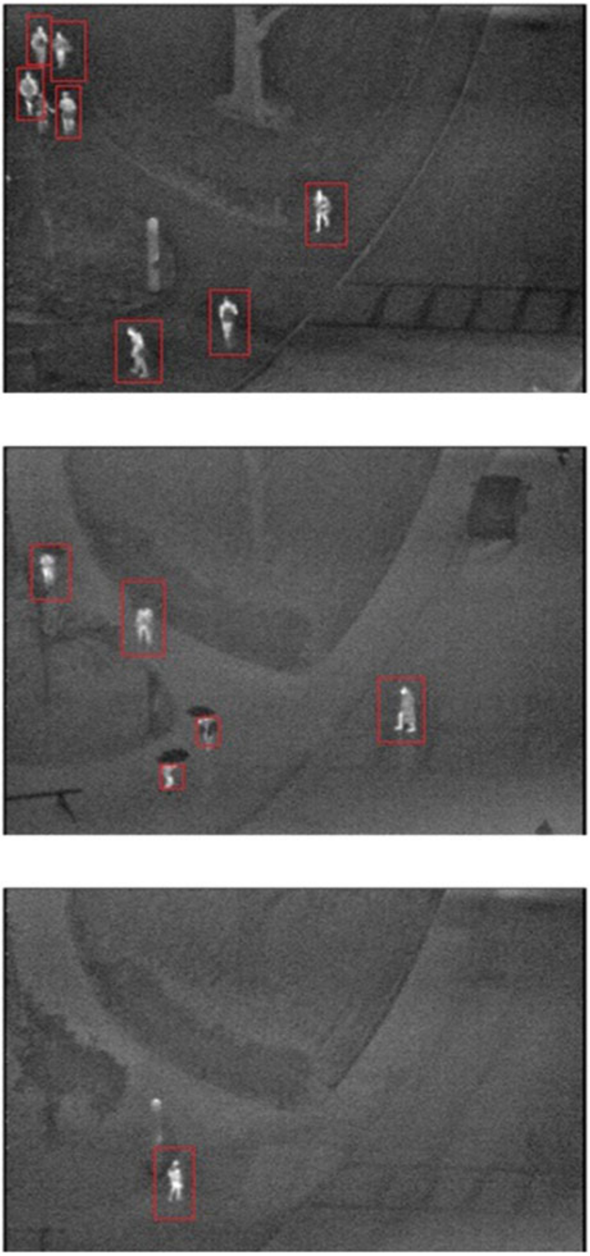
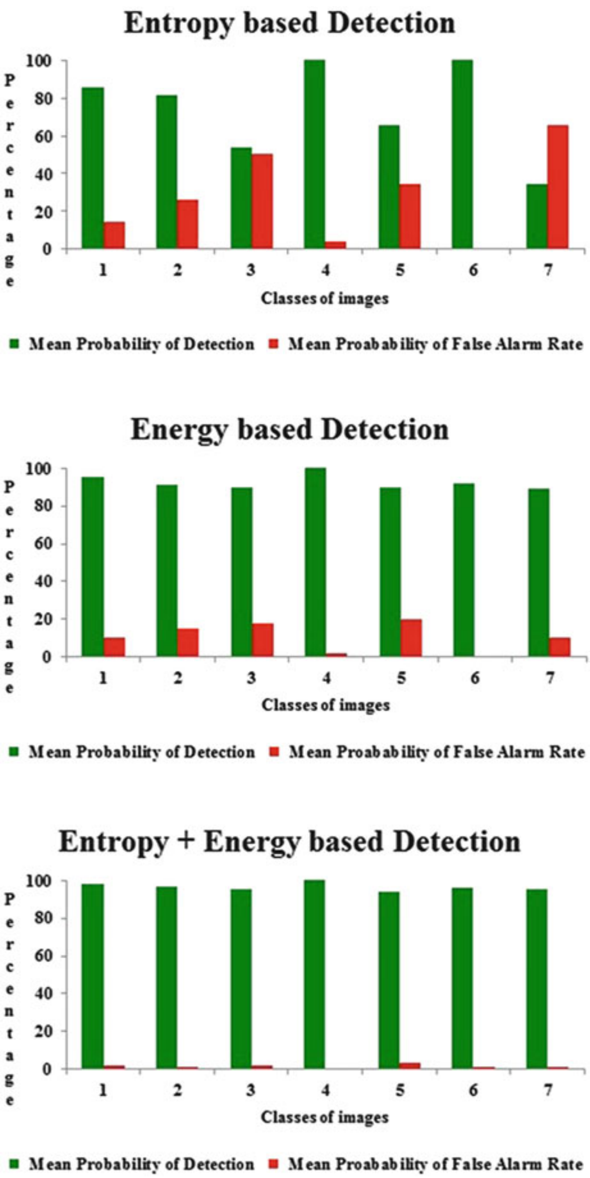


Fig. 4 Detection rate and false alarm rate over the three proposed approaches



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