Algorithm for Target Detection in a Camouflaged Scene

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Abstract

This paper focuses on the detection of target object from various kinds of objects and camouflaged scene. We offer to apply a target detection method that developed based on the nonlinear correlation approach. The hidden target is extracted by ortho-normalization and normalized correlation between camouflaged scene and target vectors. Uniform intensity transformation technique is applied for both of them. Target positions can be detected not only for the same size of the target in a scene but also detect the various sizes and various oriented target included in scene. Several experiments in both noiseless and noisy environment have been done to confirm the effectiveness of the proposed system.

1. Introduction

Many pattern recognition techniques use the correlation operation to detect targets from the scene. Normalize correlation method is one of the well known approach in optical pattern recognition. The normalize correlation based on the Cauchy-Schwarz inequality applied to the arbitrary correlation filters. We propose an object recognition method based on an orthonormal vector space basic representation to detect target objects in scenes. The proposed method which is detected not only the invariant intensity of object and scene but also independently from other restricted conditions. Nonlinear filtering approach is applied for intensity invariant recognition algorithm. The filtering is achieved by two functions that include target object and scene. This method is not only intensity invariant but also has good discrimination and resistance to noise. The multiple objects are detected from a camouflaged scene. Camouflage is the process of masking the foreground to appear as through its background. Some animals are camouflaged to blend in with their surroundings. It is also frequently used by animals and humans in order to conceal objects from visual surveillance or inspection. Man-made materials, such as prefabricated nets, net sets, wire netting, snow fencing, truck tarpaulins and smoke are applied in military units.

There are some relative research works of the camouflaged target detection. One illumination model that is widely used has a target that is multiplied by an unknown constant factor so that the correlation peak will change by the same amount and in such cases dark targets can be missed. The two types of intensity transformation, multiplicative and additive are considered for computing the light source intensity changes [4], [5]. Additive-intensity transformation is useful for different camera settings or when scattered light enters the camera. A. C. Copeland and M. M. Tivedi [1] present a framework for evaluating metrics for the search and discrimination of a natural texture pattern from its background. ACE metric computing is applied for measuring the target distinctness and target position in natural scene. Tankus and Y. Yeshurun [2] developed the camouflage breaking method based on the convex patches. They used an operator (Darg) to create an output image whose intensity level is a reflection of the convexity of the original image. Their method can allow for detecting the oriented target.

In this paper, the positions of the target object are detected in a camouflaged scene contains the multiple object. The invariant under any linear-intensity transformation of object is analyzed for object segmentation. Adaptive contrast invariant approach is applied to get the correlation peak. From the point of view of vector spaces, pattern recognition consists of recognizing vectors independently of their length, which can be viewed as an angle measurement between vectors in vector spaces. This angle provides a measure of the similarity between the object and the reference functions. In addition to the definition of an orthonormal vector space basis used to detect objects independently of the illumination. The camouflaged targets under various conditions and different orientation can be detected by our propose system.

1. Camouflage Pattern, Target Image and Camouflaged image

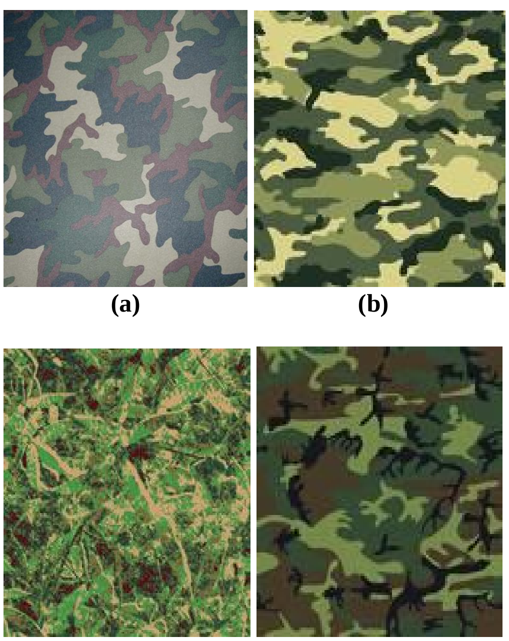
Camouflaged images are obtained by adding the target image and camouflage pattern under the various intensities. The linear combination of intensity over a target can be written as

$$f'(x)=af(x)+b\phi(x), \qquad (1)$$

where a and b are the threshold values. $f(x)$, $\phi(x)$ and $g(x)$ are the target image, its binary image and camouflage pattern, respectively. The camouflaged image is created by hidden the target image $f'(x)$ under the camouflage pattern $g(x)$ with the various intensity of the target image. Then the camouflaged image is

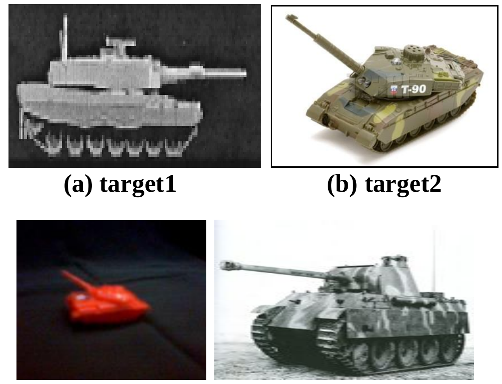
$$f'(x)=af(x)+b\phi(x)+cg(x), \qquad (2)$$

where a, b and c are the threshold values. Figure1 and Figure2 describe some camouflage patterns and the reference targets, respectively. Figure3 shows the camouflaged images which contains the various scale and orientation of the reference target.



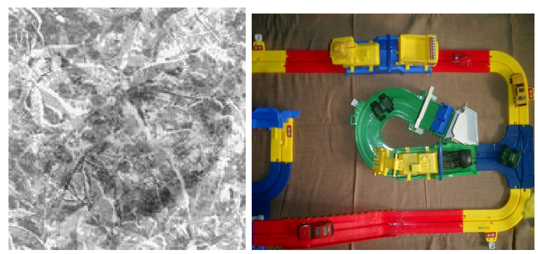
(a) (b) (c) (d)

Figure 1. Some camouflage patterns



(a) target1 **(b) target2** **(c) target3** **(d) target4**

Figure 2. Some target images.



(a) **(b)**

Figure 3. Camouflaged scenes

3. Target Detection in Camouflaged Scene

3.1 Zero Mean Targets

An image can be considered as a vector and represented by orthonormal vector to the silhouette $\phi(x)$. By vector addition law, $\phi(x)$ and its orthogonal vector $f_0(x)$ can be defined as,

$$f_0(x) = f(x) - \mu_f\phi(x), \qquad (3.1)$$

where μ_f is the mean of $f(x)$ and $\phi(x)$ is the binary object support that is equal to unity over the support of the target $f(x)$ and equal to zero everywhere else, and a and b are unknown constants. Then the orthonormal vector $f_0(x)$ is called a zero mean target. The target also can be defined as a linear combination of two orthogonal images (a silhouette and a zero-mean target) as

$$f'(x)=a'f_0(x)+b'\phi(x), \qquad (3.2)$$

The unit length ϕ_1 and ϕ_2 of $f_0(x)$ and $\Diamond(x)$ can be obtained by normalization.

$$\phi_1 = \hat{\Diamond}(x) = \Diamond(x)/\|\Diamond(x)\|; \quad \phi_2 = \hat{f}_0(x) = f_0(x)/\|f_0(x)\|,$$

where $\|f_0(x)\|$ is the correlation of $f_0(x)$ and itself.

3.2. Zero-padding and Filtering Operation

Before finding the cross-correlation between the two images, the target image is needed to perform the zero-padding for equal size and preventing aliasing.

(a) target image (b)added image

Figure 4 The result of zero padding image

Let $s(x)$ is the scene image and $\hat{f}_0(x)$ be the orthonormal basis of zero-mean target. To find the filtering operation, the correlation between them is computed firstly.

$$[s(x) * \hat{f}_0(x)]^2 = a''^2 \qquad (3.3)$$

Then, the correlation between scene $s(x)$ and silhouette $\Diamond(x)$ is computed.

$$[s(x) * \hat{\Diamond}(x)]^2 = b''^2, \qquad (3.4)$$

The correlation peak can be obtained by calculating the following correlations:

$$[s^2(x) * \hat{\Diamond}(x)] = \frac{1}{\sqrt{N}}(a''^2 + b''^2); \qquad (3.5)$$

where N is the number of pixels in the support of the object $f(x)$. So the final filtering operation at the output will be

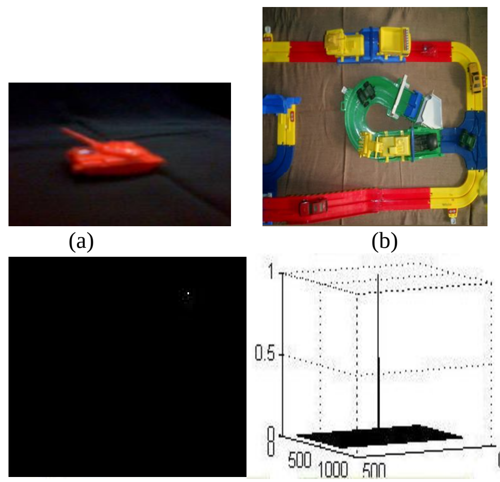
$$C(x) = \frac{[s(x) * \hat{f}_0(x)]^2}{\sqrt{N} \quad [s^2(x) * \hat{\Diamond}(x)] - [s(x) * \hat{\Diamond}(x)]^2} \qquad (3.6)$$

Then, if $s(x)$ is a linear combination of the orthonormal basis, the correlation peak will be equal to one and will be smaller than one if it is not. This technique is equivalent to projecting the scene onto the subspace orthogonal to $\Diamond(x)$, that is, to project the zero-mean scene in this region of support and then to calculate the cosine of the angle between the scene and the reference. Then, the angle between this projected vector $s(x)$ and $f_0(x)$ is described as,

$$C(x) = \cos^2\theta. \qquad (3.7)$$

4. Experimental Results

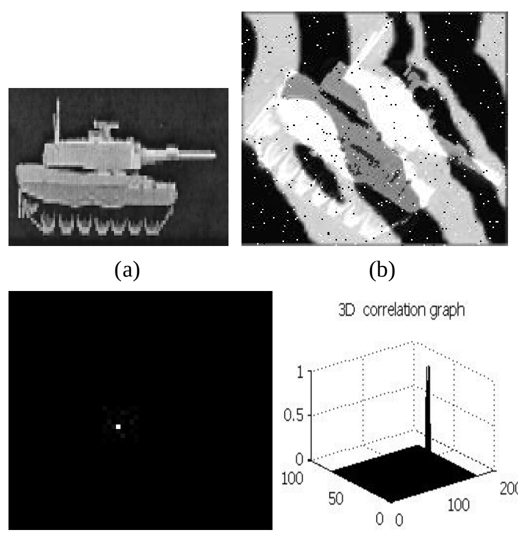
Several experiments have been done to confirm the effectiveness of the proposed method. Image of reference object is grabbed by Nikon Coolpix 7600 digital camera. Firstly, the detection of single target in a camouflaged scene contains multiple objects is considered. Target image, the real scene image, correlation space and 3D correlation graph are illustrated in Figure5. The processing time for single target detection is nearly 3 seconds.



(a) (b)

(c) (d)

Figure 5. Desired target detection

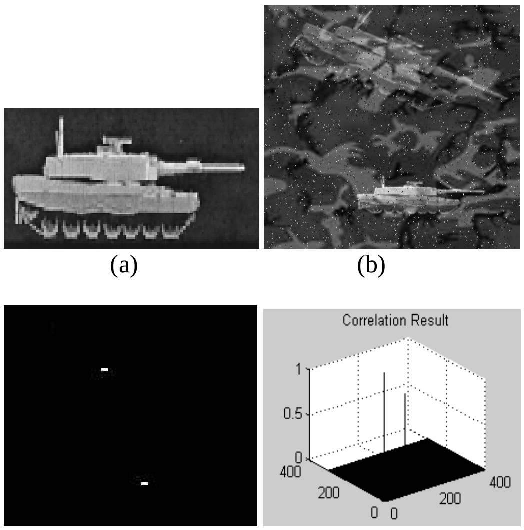


(a) (b)

(c) (d)

Figure 6. Target detection in noisy environment

Secondly, we consider the detection of the single target position of target in noisy environment. Figure6 show the target image, noisy scene image, correlation plane and 3D correlation graph, respectively. The detection time for a target in noisy environment is about 4 seconds. Next, Figure7 illustrated the detection of the different scale and oriented target in a scene image.



(a) (b)

(c) (d)

Figure7. **Multiple target detection**:

Generally, the processing time depend on the number of target position, target size and orientation. In our experiments, the processing time for the multiple targets in various conditions is about 11 seconds.

5. Conclusion

An algorithm for detection the target positions from a camouflaged scene containing the multiple objects are proposed in this paper. Several experiments with both of the real scene and simulated camouflaged scene are in noiseless and noisy environment. Target positions are detected not only for the same size of the target in a scene but also detect the various sizes and various oriented target included in scene. The desired target (true target) also can be detected in a scene contains the multiple different objects with various scale. The detection errors occur nearly 10%. The processing time is taken about 3 to 12 seconds. The detection of the true target with various orientations will be considered in the next step.

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