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# Implementation of Weighted Structure Similarity & Texture Parameters for Camouflage Texture

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## Abstract

*Camouflaging is the art of disguising an object to blend the object in a similar background. In this paper method for camouflage texture analysis is proposed. A camouflage texture analysis method based on Weighted Structure Similarity (WSSIM) and Natural Image Parameters between Camouflage texture and background image which are calculated and compared to help to direct the designing camouflage texture. Primary experimental results and comparisons demonstrate that the implemented method is helpful for designing camouflage texture.*



## 1. Introduction

The term camouflage comes from the French word camoufler meaning to blind. Camouflage also called protective concealment , means to disguise an object in plain sight , in order to conceal it from other environment.

The simple straight forward requirement in camouflaging an object is to enclose an object in such texture of matching background that human eyes fail to detect the target. In the extended version the target detection even by powerful telescope or remote sensing camera would also be difficult, so it is very important to evaluate whether camouflage texture spots are consistent with the background in the shape, size, color and spatial distribution, traditionally there is limitation and short comings like physiological factors of the observers and testing environment in image quality subjective evaluation.

In last two decade many objective evaluation methods were proposed to assess camouflage texture. Sengottuvelan [2] employed the GLCM and Dendogram for natural image to identify the camouflage object. Thomas [4] built up a software system for the camouflage assessment of object in image sequences. Venkata Rao [10] describes an image quality assessment technique which is based on the properties of the human visual system (HVS). It combines the notions of structural similarity with visual regions of interest. Xiaopend Li [3] used Spectrum features as well as texture features of multi-spectral image between target and background, then calculating mahalanobis distance of spectrum features as well as texture features data vector. Nagappa [6] employed co-occurrence matrix to compute texture features within small region of the image. Then defective portions were detected by cluster analysis and identified through watershed segmentation.

In this paper we implement a weighted structure similarity and natural image features to evaluate the perceived difference between camouflage image texture and background image.

## 2. Camouflage Texture Evaluation

### A. Weighted Structure Similarity

A variety of basic operation is performed to eliminate distortion from background image and camouflage texture. And a low-pass filter simulating the point spread function of the eye optics may be applied. Let $X = \{xi|I = 1,2,\ldots,N\}$ and $Y = \{yi|I = 1,2,\ldots,N\}$ be two discrete non-negative signals that have been aligned with each other (e.g., two image patches extracted from the same spatial location from two

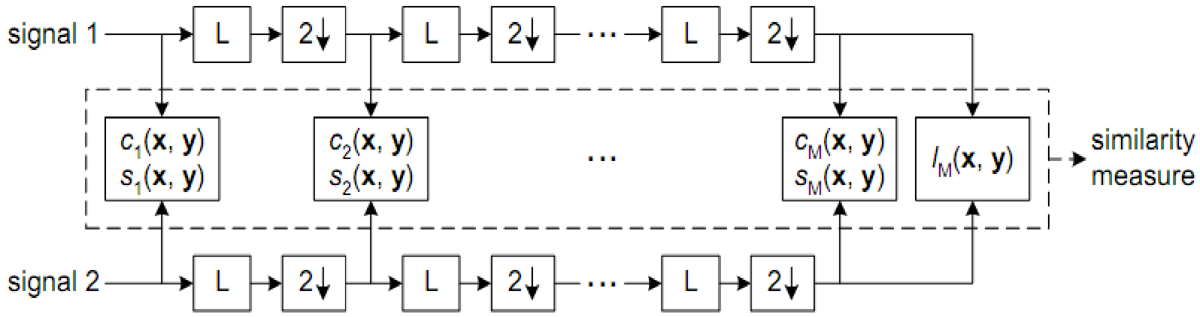



Fig. 1. SSIM measurement system L: low-pass filtering; 2↓: downsampling by 2.

images being compared, respectively), and Let $\mu x$, $\sigma x$ and $\sigma xy$ be the mean of X, the variance of X and the covariance of X and Y respectively. Approximately, $\mu x$ and $\sigma x$ can be express in terms of the luminance and contrast of X, and $\sigma xy$ measures the tendency of X and Y to vary together, which indicates the structural similarity. In [6] the luminance, contrast and structure comparison measures were given as follows :

$$l(x,y) = \frac{2\,\mu_x\mu_y + C1}{\mu_x^2 + \mu_y^2 + C2} \qquad (1)$$

$$c(x,y) = \frac{2\sigma_x\sigma_y + C2}{\sigma_x^2 + \sigma_y^2 + C2} \qquad (2)$$

$$s(x,y) = \frac{2\sigma_{xy} + C3}{\sigma_x\sigma_y + C3} \qquad (3)$$

Where C1, C2 and C3 are small constants included to avoid instability.
At last, the structural similarity (SSIM) index between X and Y can be drawn as

$$SSIM(x,y) = l(x,y)c(x,y)s(x,y) \qquad (4)$$

The camouflage texture is compared with each block of the background with same size to get the whole evaluation result by weighted structure similarity as follows:

$$WSSIM(X,Y) = \frac{1}{M}\sum_{j=1}^{M} w_j\, SSIM(x_j, y_j) \qquad (5)$$

Where $w_j$ is the weight of different block of background and M is the sum of the blocks.

The structural similarity measurement system diagram is illustrated in fig. 1. Taking the background image and the camouflage image signals as the input, the system iteratively applies a low- pass filter and down samples the filtered image by factor of 2. At the $j^{th}$ scale the contrast comparison (2) and the structure comparison (3) are calculated and denoted as $c_j$(x, y) and $s_j$ (x,y), respectively. The luminance comparison (1) is computed only at scale M and is denoted as $l_M$ (x,y). The overall SSIM evaluation is obtained by combining the measurement at different scales.



## B) Nature Image Feature Analysis

Natural image signals are highly structured [13], their pixels exhibit strong dependence which carries important information about the structure objects in visual scene. Structural features of natural images can be used to evaluate the effects of camouflage texture. We select some natural image features for directing the design camouflage texture[9]. The selected features are summarized in the following [14]

- **Average Luminance** :

$$\mu = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad (6)$$

Where N is the sum of image Pixels.

- **Standard deviation :**

$$\sigma_x = \left(\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \mu_x)^2\right)^{1/2} \qquad (7)$$

- **Correlation length**, which can be convenient from image Fourier spectrum.

$$r = 10.0/w \qquad (8)$$

Where,

$$W^2 = \frac{\sum(U^2 + V^2)|F(U,V)|^2}{\sum|F(U,V)|^2} \quad (9)$$

where F(U,V) with U and V as a variables is image Fourier spectrum.

- **Texture direction**, which is the angle of peak of the power spectrum:

$$P(u,v) = |F(U,V)| \quad (10)$$

- **Image Entropy** :

$$H(I) = -\sum_{i=0}^{L-1} \frac{Ci}{N} log_2(\frac{Ci}{N}) \quad (11)$$

Where N is sum of image pixels, L is sum of classes, and C is the pixels number of every class.

- **Edge Detection:** By edge detection the number of closed areas and the length of edge can be got. Background image and camouflage textures are treated with canny edge detector to extract the image edges [15].

So, all these features can measure the difference between camouflage texture and the background image, so according to the differences (e.g. luminance etc.) designers are able to improve the camouflage textures.



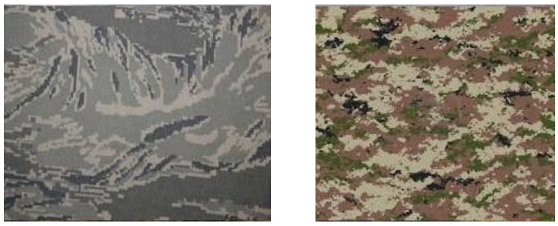
## 3. Experimental Results and Discussion

The camouflage texture is evaluated based on WSSIM and nature image feature analysis in fig.2 (a) is the background image and Fig.2 (b) (c) and (d) are the camouflage textures for analysis. In Fig.3, the blue box area is compared with the eight neighbor areas. In fig.3 (a) is the background image (b), (c) and (d) are the camouflage textures. the table I gives test results.

From table I it is clear that texture 2 is better than texture 1 and texture 3, which is consistent with the subjective evaluation.

According to these experimental results, designers know whether to accept the camouflage texture and how to improve the camouflage texture.

(a) Background image (b) Camouflage texture1



( c) Camouflage texture 2 (d) Camouflage texture3

Figure 2. Background image and Camouflage textures

(a) (b)

(c) (d)

Figure 3. Background image and Camouflage textures.

## 4. Conclusion

In this paper we implement a WSSIM approach for camouflage texture evaluation and nature image parameter is incorporating the variations of camouflage image resolution and viewing conditions which have the greatest effect on detection. However, this approach is still rather crude. We are working on developing it into a more systematic approach that can potentially be employed in much broader range of application.

**Table 1. Normalized Features Values**

| Parameters | Original image | Texture 1 | Texture 2 | Texture 3 |
|---|---|---|---|---|
| Deviation of luminance | 1 | 0.0947 | 0.0956 | 0.0978 |
| Image entropy | 7.7130 | 7.7092 | 7.7137 | 7.7167 |
| Correlation length | 0.9797 | 0.9791 | 0.9797 | 0.9787 |
| No. of closed areas | 3844 | 3855 | 3890 | 3817 |
| Index of similarity | 1 | 0.9890 | 0.9889 | 0.9888 |

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