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Wavelet fusion for encrypting images with a few details

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ABSTRACT

This paper introduces a new scheme for encrypting images with a few details based on wavelet fusion. In this scheme, the image with a few details to be encrypted is fused with another image that is rich in details utilizing the Discrete Wavelet Transform (DWT) prior to encryption. The fusion is a pre-processing step to change the homogeneity of flat areas in the images having a few details. RC6 or chaotic Baker map encryption are then performed on the fused image. Encryption with chaotic Baker map is just a permutation algorithm that cannot perform well on flat areas of the images, because the permutation yields approximately the same intensities. So, circular shifts on pixels are performed on the fused image prior to chaotic encryption to remove flat areas or reduce the degree of homogeneity. Chaotic encryption is then performed in the wavelet domain to increase the degree of diffusion. Several metrics are used in this paper for performance evaluation of the suggested ciphering schemes like visual inspection, histogram test, encryption quality analysis, and diffusion analysis. The robustness of the suggested image ciphering schemes is tested in the presence of noise before decryption. Simulation results demonstrated that the suggested image ciphering schemes provide a secure and effective way for encrypting images with few details.

1. Introduction

Now, the security becomes a significant problem in telecommunication and image protection. Ciphering is considered as an efficient method to realize security. Image ciphering is employed in video conferencing, mobile multimedia systems, military communications, telecommunications, and telemedicine [1,2]. Image ciphering schemes are divided into confusion-based schemes and diffusion-based schemes. Encryption for the purpose of transmission over wireless channels is preferred to be implemented with confusion-based schemes, because diffusion-based schemes are sensitive to the accumulation of errors [3]. So, chaos-based algorithms have shown their superiority for image encryption [4].

Encryption of images with few details is a challenging task for most encryption algorithms. Block cipher algorithms like the RC6 algorithm fail in hiding the details of these images, because the pixel values incorporated into the encryption of a certain

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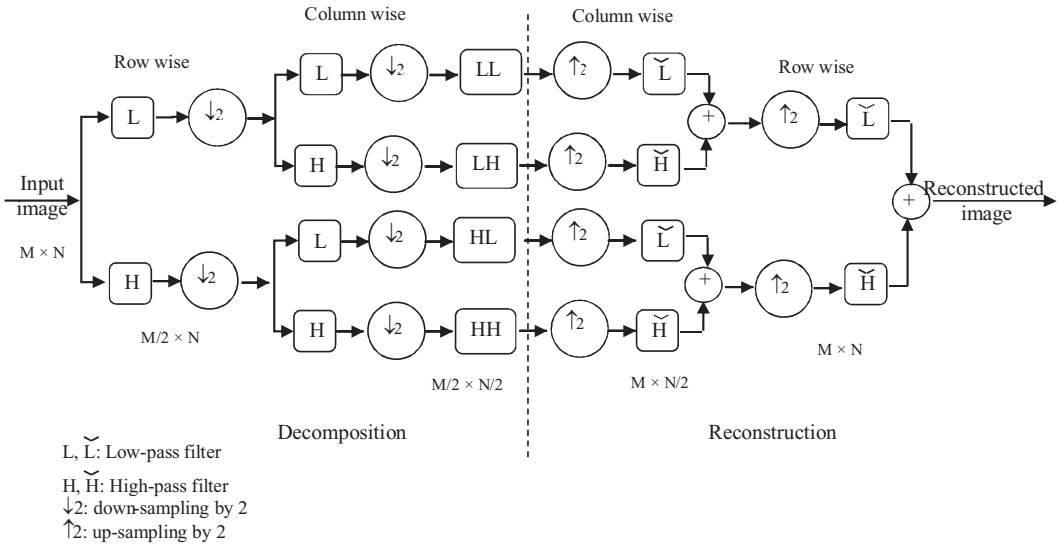

Fig. 1. One level image decomposition and reconstruction by a 2-D DWT.

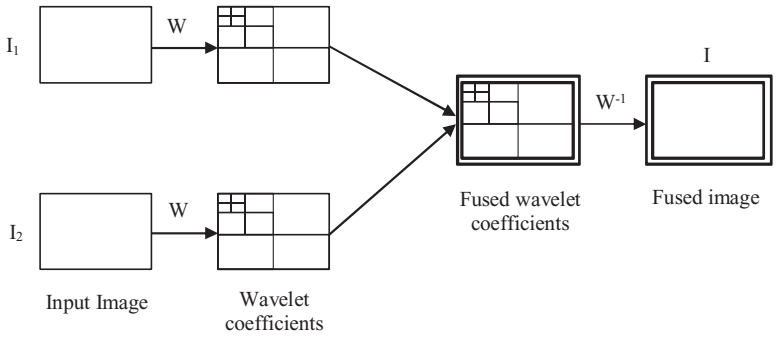

Fig. 2. Wavelet fusion of two images.

area of the image are very close. Also, spatial domain chaotic ciphering has a disadvantage of keeping an identical histogram to that of the plainimage. A solution to such problem is based on performing some type of pre-processing on the image prior to encryption to remove homogeneity of flat areas. This pre-processing step can be a fusion with another image that is rich in details.

Image fusion can be considered as a process that merges different images together to construct a single image [6–9]. In this paper, the target is totally different from that of traditional fusion algorithms, which aim at integrating information from different realizations of the same scene. Fusion is performed here with a totally different image from the image to be encrypted to create as much randomness as possible in the obtained image. This process is expected to increase encryption efficiency.

The remaining paper sections are arranged with the following order. Section 2 presents image fusion with the wavelet transform. Section 3 introduces the suggested image ciphering schemes. Section 4 presents results and analysis. Noise effect on the decryption process is explored in Section 5. In Section 6, conclusions are given.

2. Wavelet-based image fusion

The DWT represents a compromise between the spatial and frequency domain representations. The DWT processes the signal at various frequency bands with various resolutions through decomposing the signal into a low frequency component (approximation) and high frequency components (details). The DWT employs scaling and wavelet functions. The 2-D DWT is employed through performing a 1-D DWT on rows and columns of the 2-D data. Fig. 1 shows the process of applying the 2-D DWT to an image with a bank of filters, where L and H represent low-pass and high-pass filters, respectively, and $\downarrow 2$ denotes the down sampling by two. The finite impulse response filter coefficients of the low-pass and

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