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Quality enhancement of infrared images using dynamic fuzzy histogram equalization and high pass adaptation in DWT

Athar A. Ein-shoka [a], Osama S. Faragallah [a,b]

[a] Department of Computer Science and Engineering, Faculty of Electronic Engineering, Menoufia University, Menouf 32952, Egypt
[b] Department of Information Technology, College of Computers and Information Technology, Taif University, Al-Hawiya 21974, KSA

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ABSTRACT

Recently, Infrared (IR) images have several applications in many fields, especially in the fields of medicine and military. This paper presents an efficient approach for enhancing the contrast, appearance, and quality of IR images. The proposed approach works by applying a brightness preserving dynamic fuzzy Histogram Equalization (BPDFHE) and High Pass Adaptation (HPA) function to the different frequency bands outcome after performing the Discrete Wavelet Transform (DWT) on IR image to be enhanced. The coarse approximation LL band is enhanced by employing BPDFHE. The HPA is applied to the horizontal, vertical, and diagonal detail components represented by HL, LH, and HH bands, respectively. The proposed approach is tested and compared with traditional IR enhancement techniques. Experimental tests ensure the superiority and efficiency of the proposed approach in enhancing contrast and sharpening the edges of the low contrast IR images.

1. Introduction

IR images are greatly suffered by thermal characteristics of the traced objects and surrounding view. Practically, the camera optimal settings cannot ensure optimal displayed image from human's point of view [1]. IR images suffer from a lot of problems such as low image quality, low contrast, resolution, and difficulty to detect objects. This is because IR images contain wide black portions and tiny details due to light absence needed for imaging, and there is no difference between objects and their background [1]. These problems limit the overall performance of IR images and makes difficult to detect objects which is the backbone of many applications like military, medical, detect diagnoses. . ..etc [2–3]. So image processing is needed to enhance the original IR images. Contrast enhancement is considered of great importance in image processing and target recognition. Contrast enhancement techniques are classified into global and local contrast techniques. Global contrast enhancement techniques are simple and powerful but cannot adapt to the local brightness features of the image because they use only global information collected over the entire image. These techniques may include histogram equalization, fuzzy logic, retinex, and homomorphic filtering. Local contrast enhancement techniques adjust pixels values of the image to improve the visualization of both darkest and lightest portions of the image at the same time. These techniques focused on improvement of histogram equalization. The BPDFHE is one of local contrast enhancing techniques [19].

The goal of contrast enhancement is to improve the appearance of the IR images, make edges of the object clearer so that the object can be easily determined, extracted and more information can be obtained, differentiate objects easily, and improve clarity of object features. So, IR images will be more effective for many applications. So, this paper concentrates on enhancing the contrast because it is a very important factor that affects IR images [4].

The paper proposes an efficient approach to enhance IR images contrast. We concentrate on contrast and edges of the IR images which are the main problem which IR images suffer from. This method depends on performing BPDFHE and

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0030-4026/

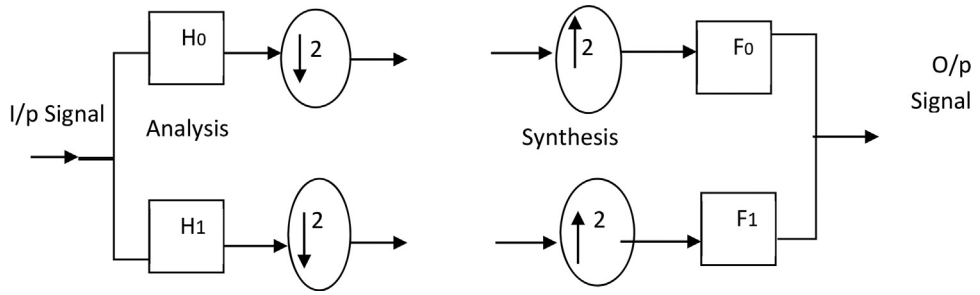

Fig. 1. The analysis and synthesis processes.

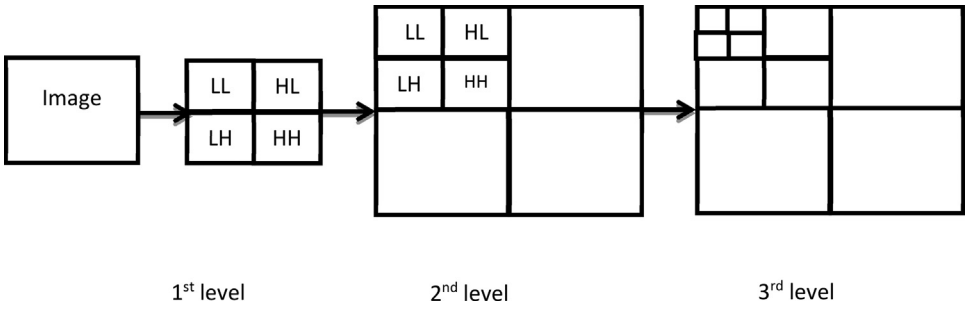

Fig. 2. Three Level DWT Decomposition.

HPA function on wavelet coefficients after applying DWT. The proposed IR enhancement approach aims at obtaining the following:

1 Further enhancement in the contrast of the IR images using the proposed approach.
2 Edges intensity have greater enhancement using the proposed approach.
3 The proposed approach takes less time compared with other enhancement techniques.

A Comparative analysis is held between the proposed approach and traditional enhancement approaches like homomorphic filtering [2,5,6], Adaptive modification of local contrast and local luminance mean (non-linearity) [8], single scale retinex (SSR) [7,9–10], multi-scale retinex (MSR) [11–13], fuzzy logic [14–17], additive wavelet homomorphic approach [2] and BPDFHE approach [19]. The obtained results show the superiority and efficiency of the proposed approach compared with other traditional IR enhancement techniques.

The paper rest is arranged as follows. Sect. 2 discusses the DWT. In Sect. 3, the proposed IR enhancement method is presented and the BPDFHE, HPA function is explained. In Sect. 4, the evaluation metrics for measurement are explained. Sect. 5 presents experimental results. Finally, conclusions and future works are given in Sect. 6.

2. Discrete wavelet transform (DWT)

In the frequency transform domain, images are segmented into multiple bands. These transforms are utilized for enhancement through changing the image coefficients in the transform domain and then performing the inverse transform to obtain the enhanced image. In this paper, we utilized the DWT since it is one of the most important transformation due to its simplicity (easy to implement, flexibility, and it reduce the time and resources used). Wavelet transform uses many different filters. The filter decomposes the image into several frequencies. These frequencies are LL, HL, LH, and HH bands that represent the approximation image, the horizontal, vertical, and diagonal detail components respectively. The process of DWT is done by passing the input signal through filters with different scales, and frequencies. These filters are low pass filter (H_0) and high pass filter (H_1), then followed by 2:1 down sampling. We obtained low pass details x_0 and high pass details x_1. Then repeat this process again on the resulted low pass component. . ...etc. In the reverse process, we also applied two filters (low and high) and before them up sampling process takes place. This process called synthesis, as shown in Fig. 1 [18].

The DWT divides the image after analysis into four different frequency bands with different resolutions, which represent the detail coefficients and coarse approximation of the image analyzed. If the LL component of the image analysis stage using DWT is taken, and DWT is applied again and that process repeated more than once, we will have a multilevel decomposition, and that is called also pyramid decomposition as shown in Fig. 2. The DWT coefficient magnitude is larger in the LL band and smaller for HL, LH, HH bands. So, LL which has lower resolution can be easily enhanced by BPDFHE, and LH, HL, HH which have higher resolution can be easily locate their edges and texture patterns of the image, so, it enhanced with HPA function.