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Fusion of Fuzzy Enhanced Overexposed and Underexposed Images

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Abstract

An image fusion algorithm based on DWT is used to combine fuzzy enhanced overexposed images and underexposed images. The proposed method provides fused image containing visual salient information present in both the input images along with significant contrast enhancement. The proposed algorithm is useful for a wide range of applications such as military applications, surveillance, medical diagnosis etc. The fused image obtained from DWT fusion of fuzzy enhanced images is visually better than those obtained from DWT fusion of: unenhanced images, gamma corrected images as well as histogram equalized images. Both subjective and objective assessment is performed to evaluate the performance of the proposed algorithm. The objective image quality measures: entropy and standard deviation, also shows that the proposed method performs better than the other method.

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Keywords: Fuzzy image enhancement; Gamma correction; Illuminated images; Image fusion; Discrete wavelet transform (DWT).

1. Introduction

Image fusion[1] is a process which correlates and combines two or more input images into a single image containing maximum possible information present in individual images. The objective of this process is to combine multiple images by reducing uncertainty, minimizing redundancy and maximizing information relevant to a particular application. The process of image fusion results in wider temporal, spatial and spectral coverage. Image fusion techniques are widely used in the fields of medical diagnostics, remote sensing, military applications, surveillance, etc. The process of image fusion is divided into three levels[2,3]: pixel – level, feature – level and decision – level, depending upon the stage at which fusion takes place. In pixel level (low level) image fusion, the fusion process works directly on the pixels of the input image and is preferred when the images to be fused are provided by the alike sensors. Pixel – level fusion algorithms works either in the spatial domain or in the transform domain. Feature level (mid level) image fusion works on features extracted from the input images and are very much image dependent. Decision level (high level) image fusion works at the highest level and combines the interpretations of different objects obtained from input images. Decision level algorithms are suitable when the input images to be fused are provided by very different sensors. The images to be fused may suffer from different image degradations[8]. Underexposed images may be affected by noise whereas over-exposed images may suffer from motion blur. The fusion process should be

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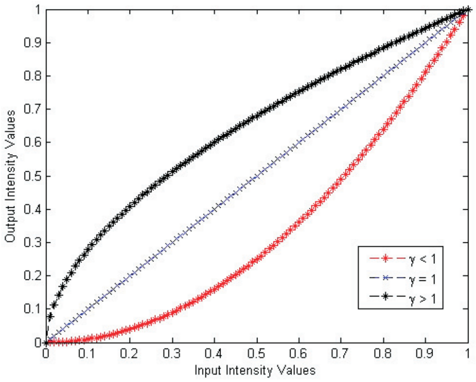

Fig. 1. Gamma correction curves.

such that it preserves the sharpness of edges from underexposed images and low noise characteristics of overexposed images. Thus, the proposed method uses fuzzy based image enhancement to improve the visibility of underexposed and over-exposed images and then uses discrete wavelet transform to fuse these enhanced images. The performance of the image fusion algorithm depends on the right intensity fusion of registered images. The rest of the paper is organized as follows: Section 2 and 3 discusses Gamma Correction (GC) algorithm and Histogram Equalization(HE), Section 4 presents detail of the proposed fusion method based on Fuzzy Enhancement(FE), Section 5 gives results and discussion and finally, conclusion is drawn in Section 6.

2. Gamma Correction

A non-linear transfer of signal exists between an electrical device and an optical device. This non-linearity causes serious distortions in the intensity of image, resulting with certain areas being too dark and with certain areas being bleached out.

To compensate for this non-linearity, an image processing algorithm called gamma correction is applied to the video signal to produce an image with fidelity. Thus, gamma is an important characteristic of all digital imaging systems which defines the relation between a pixels value and its actual luminance. Gamma correction is a non-linear transformation used to control the brightness and contrast of an image. It is used in image processing to compensate for non-linear relations in imaging sources, displays and printers. It not only changes the overall brightness of an image but also the ratio of red to blue to green. If images are not properly corrected, they are of poor quality and has reduced predictability of texture and colors. The gamma correction[4] function is a monotonic function producing output pixel intensity, $X(i, j)$ which is proportional to inverse of gamma power of input pixel intensity, $x(i, j)$ and is defined as

$$X(i, j) = 255 \times \left(\frac{x(i, j)}{255}\right)^{\frac{1}{\gamma}} \tag{1}$$

Figure 1 shows the gamma curves. It can be observed that the gamma corrected image is lighter than the original image for $\gamma < 1$ and is darker than the original image for $\gamma > 1$.

3. Histogram Equalization

Let $X = \{x_{ij}\}$ be a digital image of size $M \times N$ and r_j for $j = 1, 2, 3, \ldots, L$ be the L intensity level of the input image. Let $p(r_j)$ be the histogram associated with the intensity levels of input image which are approximations to the probability of occurrence of intensity level, r_j for $j = 1, 2, \ldots, L$ in a given image, i.e.

$$p(r_j) = \frac{n_j}{(M \times N)} \tag{2}$$