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Microscopic image contrast and brightness enhancement using multi-scale retinex and cuckoo search algorithm

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Abstract

Image enhancement is widely used technique to analyze various types of digital photography (e.g. biomedical, microscopic, remote sensing, and etc.) in domain of digital imaging processing. This paper proposes a new contrast and brightness enhancement technique based on Cuckoo Search (CS) and Multi-scale Retinex (MSR) algorithm for quality improvement of the microscopic images. Practically, the MSR generally delivers the similar parametric value to the Gaussian filters with different scales. Consequently, it not suitable for the superior enhancement in different circumstances. To handle this problem, we utilize CS to select fittest parametric values to optimize the performance of MSR. The optimization of parameter selection is significantly balances the imperfections of the scale parameters in Gaussian filters. The experimental results show the excellence of the proposed method in enhancement in terms of PSNR, MSE, Mean and Standard Deviation compared with performance of conventional MSR and other state-of-art techniques.

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Keywords: Microscopic image, image enhancement, multi-scale retinex, gaussian filter, cuckoo search, particle swarm optimization, artificial bee colony algorithms.

1. Introduction

Digital microscopic image processing and analysis widely researched field in the domain of image processing. Thus the microscopic image requires to be enhanced for improving the quality of color microscopic image for the further image processing such as edge detection, segmentation, feature extraction, etc[1,2]. Image enhancement approaches are mostly classified into two major categories. One is the spatial approach and the other is the transform approach. Accordingly, the previous enhances the image contrast and luminance at pixel level but the enhancement effect is unsatisfactory. The later approach can efficiently enhance image information and often reduce noise in image, consequently it is more useful[6,8]. Presently, many image enhancement techniques[2,4,8] are in use. Like in spatial domain, generalized histogram enhancement (GHE) based equalization[2,5,8], gamma correction[4,5,8], highpass filtering

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(HPF)[2,3,6], lowpass filtering (LPF)[2,6,8], homomorphic filtering, etc.[2,5,8] are often are considered. In transform domain, discrete cosine transform (DCT)[2,5,6], discrete wavelet trans form (DWT)[2,3,8], curvelet transform (CVT)[4,8], contourlet transform (CT)[2,4,5] are commonly found in contrast enhancement of images. For example, histogram equalization generates color distortion in images during the procedure of enhancement[1,2,5].

Microscopic image enhancement is a key problem while it dealing with variant lighting conditions. Superiority of microscopic image depend on various surroundings issues such as relative movement, color distortion, and uneven illumination conditions[9,10,11,15]. Retinex as simulating Human Visual System (HVS) to obtain color constancy and dynamic range fidelity[9,10,11,15]. This paper presents multi-scale retinex which effectively applies in microscopic image enhancement under uneven lighting conditions. Recent research focus on retinex, particularly on multi-scale retinex[7,10,11]. Retinex is derives using retina and cortex. For visual processing and perception, various vision organisms (e.g. retina, cone, rod cell) are controlled by visual cortex[9,10,11,15]. Retinex theory primarily includes two parts: (1) colors of objects are determined by the amount of reflect rays of light. (2) colors are invariant in irregular illumination. The Retinex is mostly computational but operational characterizes by anatomy and neuroscience[9,10,11,15]. Many researcher have been proposed various vision based using HVS model in domain of image processing such as better color correction for retinex algorithm[9,10,11], improve MSR by reducing halo artifacts and graying effect[9,15], the relationship between retinex and image compression[9,11] and improves the MSR with respect to weights of different scales of retinex[9,10,11,15]. Recently, MSR algorithms have been developed with standard mathematic models of retinex for image enhancement. Most methods consist of homomorphic filtering retinex, Poisson retinex, Single-scale retinex (SSR)[9,10], etc. Retinex implication is performed by human visual system (HVS)[11,15]. SSR uses the Gaussian surround function with single scale for filtering[9,10,11,15]. The purpose of microscopic enhancement is achieved by changing sensitivity from illumination to reflection. Multi-scale retinex (MSR) is effective to avoid the dynamic range compression[9,10,11,15]. More progression has been completed to advance the standard retinex algorithm and exploit in retinex theory to image processing.

This paper presents an improved contrast enhancement method for microscopic images using MSR and the cuckoo search algorithm with newly devised objective function, also estimated the local and intensity variation of pixels with neighboring one. Moreover, microscopic image reflectance and luminance are considered . The proposed algorithm (CS-MSR) is assessed by using it on a set of microscopic images[16] and provides truly enhance results. However, initially the proposed CS-MSR scheme has been prepared for grey-level microscopic images. After, it has been applied to enhance microscopic colour images.The strength of the proposed method (CS-MSR) gains from the evolutionary CS algorithm, which is a stochastic global optimization algorithm that is utilized for selecting the weighted parameters of MSR. The propose CS-MSR method improves better performance than the state-of-the-art MSR technique. The proposed CS-MSR method may be useful and play key role in the microscopic imaging research.

The rest of this paper is organized as follows: First introduce MSR model in Section 2. Proposed method using CS is described in detail in Section 3, and the experiment results is discussed in Section 4. The conclusion is represented in Section 5.

2. Multi-scale Retinex (MSR)

Typically, single retinex (SR) is simulate Human Visual System (HVS) which is more suitable at adapting to variation of uneven lighting condition. Source images are contains two components, i.e., the reflectance image and the luminance image[9,10,11,15]. The reflectance image establishes basic characteristics of source image and the illuminance image provides dynamic range of source image[9,10,11,15]. The intensity of point (p,q) of an given source image $I(p,q), p,q \in \mathbb{Z}$ by a logarithmic photoreceptor function can be denoted as[9,10,11,15]:

$$I(p,q) = L(p,q) * R(p,q) \tag{1}$$

where $L(p,q)$ is the flux of radiant energy (irradiance) that collapses on point (p,q) on the surface and $R(p,q)$ represents the reflectance of the source image. In that case, by taking the logarithm on both side of Eq.(1); It can be represented as

$$\log R(p,q) = \log I(p,q) - \log (I(p,q) * G(p,q)) \tag{2}$$

where $G(p,q)$ is the low-pass filter (Gaussian functions) that determines the illuminance image. The Gaussian function is normally utilized in the process of local dynamic-range resolution in neighboring pixels[9,10,11,15].The basis of the