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A novel based on parameter optimization for enhancing images

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Abstract. *Image enhancement is a very significant topic in medical image processing. This paper introduces a new algorithm about enhancing images that is based on parameter optimization. This algorithm is called the particle swarm optimization (PSO) based on Image Enhancement (PSOIE). First, from input image, the algorithm creates 3 intermediate images using basic transformations: histogram equalization, candy edge detection and median filtering. Next, we use the PSO optimization algorithm to find the optimal coefficients for each image based on the contrast index function. The output image combines three intermediate images with optimized coefficients with the following advantages: enhanced brightness, edge enhancement, image sharpening and noise reduction. The experimental results of the paper show that the proposed algorithm outperforms than some recent methods.*
Keywords: Image enhancement, wavelet, parameter optimization, particle swarm optimization.

1. **Introduction.** Image enhancement is one of the important work of image processing. Many methods have been proposed. Image enhancement includes a variety of operations such as noise removal [2] [3], unblurring, and gray-level dynamic range modification. To improve the quality of the image and visual perception of human beings, a number of enhancement methods are to be applied [4], [5]. The image enhancement methods are divided into 3 categories including histogram, fuzzy logic and optimal methods [10]. Histogram based contrast enhancing methods focus on modifying histogram of images. Histogram specification and histogram equalization are commonly used as conventional contrast enhancement mothods. Optimal methods are based on optimizing parameters. The fuzzy logic based image enhancement methods make image which quality is clearer than the traditional methods. Image enhancement techniques can be divided into two categories namely spatial domain and frequency domain methods [7]. The spatial domain method refers to aggregate of pixels composing an image, and they operate directly on the pixels of image. The frequency domain method refers to an aggregate of complex pixels resulting from taking the Fourier Transform and arises from the fact that this particular transform is composed of complex sinusoids. Due to the vast processing requirements, frequency-domain techniques are not widely used as spatial domain techniques. However, the enhancement in frequency domain is time-consuming process even with fast transformation technique, thus made it unsuitable for real time applications [8].

Fuzzy techniques are used for the enhancement of images. In [1] [6], the authors combine the fuzzy logic and the gray level adjusting formulas to enhance the contrast of images. The methods considered membership matrix and the gray level adjusting formulas to enhance contrast. However, the methods still use global approach, so they cannot solve the problem of traditional methods. In addition, the fuzzy image enhancing methods still select value of the upper, lower, and mean thresholds manually. Therefore, at no time does it select the good value, which may negatively affects the result of image enhancing. In [9], Cheng and partners proposed the algorithm of Contrast enhancement based on a novel homogeneity measurement. In [11], Kamil and Ahmet presented a method of image enhancement on MRI brain images that based on neural networks. The purpose of observe is develop an image processing algorithm for brain cancer detection on MRI images. Comparison of back propagation neural networks will be done using original images and reconstructed images on the effect of categorization. In [12], Yugander et al proposed a algorithm of MR Image Enhancement using Adaptive Weighted Mean Filtering and Homomorphic Filtering. In [13], Raman and Himanshu presented A Comprehensive Review of Image Enhancement Techniques. In [14], Swarup and et al proposed A novel Approach of Retinal Image Enhancement using PSO System and Measure of Fuzziness. In [15], Pankaj and et al proposed A novel reformed histogram equalization based medical image contrast enhancement using krill herd optimization. In [16], Jia Chen and et al proposed Adaptive image enhancement based on artificial bee colony algorithm. In [17], Malika and et al proposed Artificial Bee Colony Based Image Enhancement For Color Images In Discrete Wavelet Domain (AIEDW). In [18]], Mehwish Iqbal and et al proposed Color and white balancing in low-light image enhancement. In [19], Kai Liu and Yanzhao Tian presented Research and analysis of deep learning image enhancement algorithm based on fractional differential. In [20], Junyi Xie and et al proposed Semantically-guided low-light image enhancement. In [21], Z. Liang et al. proposed Single underwater image enhancement by attenuation map guided color correction and detail preserved dehazing. In [22], Xueyang Fu a, Xiangyong Cao proposed Underwater image enhancement with global–local networks and compressed-histogram equalization. In [23], Himanshu Singh et al. proposed Swarm intelligence optimized piecewise gamma corrected histogram equalization for dark image enhancement (SGHIE). In [28][29][30], authors presented some optimization algorithms. In [31], Chung-Ming Kuo et al. the algorithm of Histogram-Based Image Enhancement. Many meta-heuristic-based image synthesis methods have been proposed in recent years, such as MPA [32][33], GOA [34], and EOA [35][36].

Studies on image enhancement often focus on only one of the tasks: brightness enhancement, contrast enhancement, noise reduction, etc., but it is unlikely that many advantages can be achieved in the same solution. To overcome this limitation, iIn this study, we propose a new algorithm of the image enhancement based on the particle swarm optimization. The new proposal combines enhancement, denoising and edge highlighting in the same image enhancement solution so that enhanced images will achieve many advantages together. The remaining sections of this report are presented as follows: Section I introduces a short overview of enhancing images. Section II presents related works. Section III shows the algorithm about enhancing images that is based on parameter optimization. Experiments and accessments are presented in section IV. Section V is the conclusion of the article.

2. **Related Work.**

2.1. **Color space IHS.** RGB color space is very suitable for display on electronic screens. However, this color space is elusive to the human eye. Therefore, to better match the human visual system, the IHS color system is introduced:

- I is Intensity, is the characteristic property of luminous intensity.
- H is Hue, is the principal wavelength-related property in a mixture of light wavelengths. The characteristic tint for the dominant color is perceived.
- S is Saturation, characteristic of relative purity. Saturation depends on the width of the light spectrum and represents the amount of white mixed with chroma.

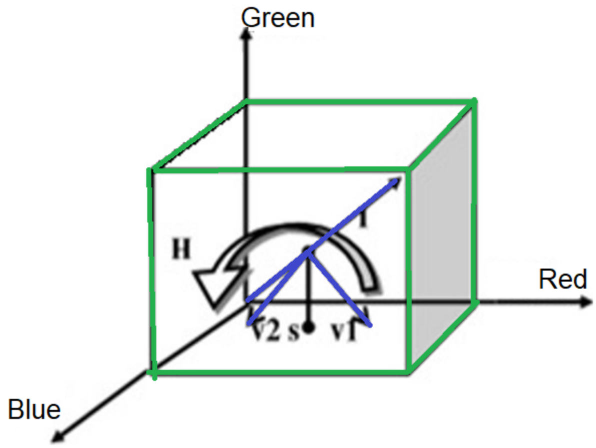

FIGURE 1. Color spaces HIS and RGB.

2.2. **Particle swarm optimization (PSO).** PSO is a algorithm about finding solutions to optimization problems [24]. Kennedy and Eberhart introduced PSO in 1995. PSO is the result of modeling bird flocks that fly to find foods. This algorithm has been applied in many fields successfully. First, PSO initialized a group of individuals randomly. Then, the algorithm updates generations to find the optimal solution. With each generation, two best positions of each individual is updated: P_{best} and G_{best}. Wherein the first value, P_{best} is best the position that has ever reached. Another optimal solution is the global optimal solution G_{best}. G_{best} is the best position in the whole search process of the population up to the present time. Specifically, after each generation updating, with each individual, its position and velocity are updated by the formula as follows:

$$PX_i^{k+1} = X_i^k + V_i^{k+1} \quad (1)$$

$$V_i^{k+1} = \omega * X_i^k + c_1 * r_1 \left(P_{best\_i}^k - X_i^k\right) + c_2 * r_2 \left(G_{best}^k - X_i^k\right) \quad (2)$$

Where:

- X_i^k: Position of the individual i^{th} in generation k^{th}.
- V_i^k: Velocity of the individual i^{th} in generation k^{th}.
- X_i^{k+1}: Position of the individual i^{th} in generation $k + 1^{th}$.
- V_i^{k+1}: Velocity of the individual i^{th} in generation $k + 1^{th}$.
- $P_{best\_i}^k$: Best position of the individual i^{th} in generation k^{th}.
- $G_{best\_i}^k$: Best position of in population in generation k^{th}.
- $\Omega = 0.729$ is the inertia coefficient.
- c_1, c_2: The acceleration coefficients, getting values from 1.5 to 2.5.
- r_1, r_2: Random numbers get values in the range [0, 1].

3. **Proposed Method.** In this section, a new algorithm for image enhancement is proposed. This algorithm is named PSO based Image Enhancement (PSOIE). The scheme of the algorithm PSOIE is shown in figure 2.

According to the above diagram, the algorithm includes the steps as follows:

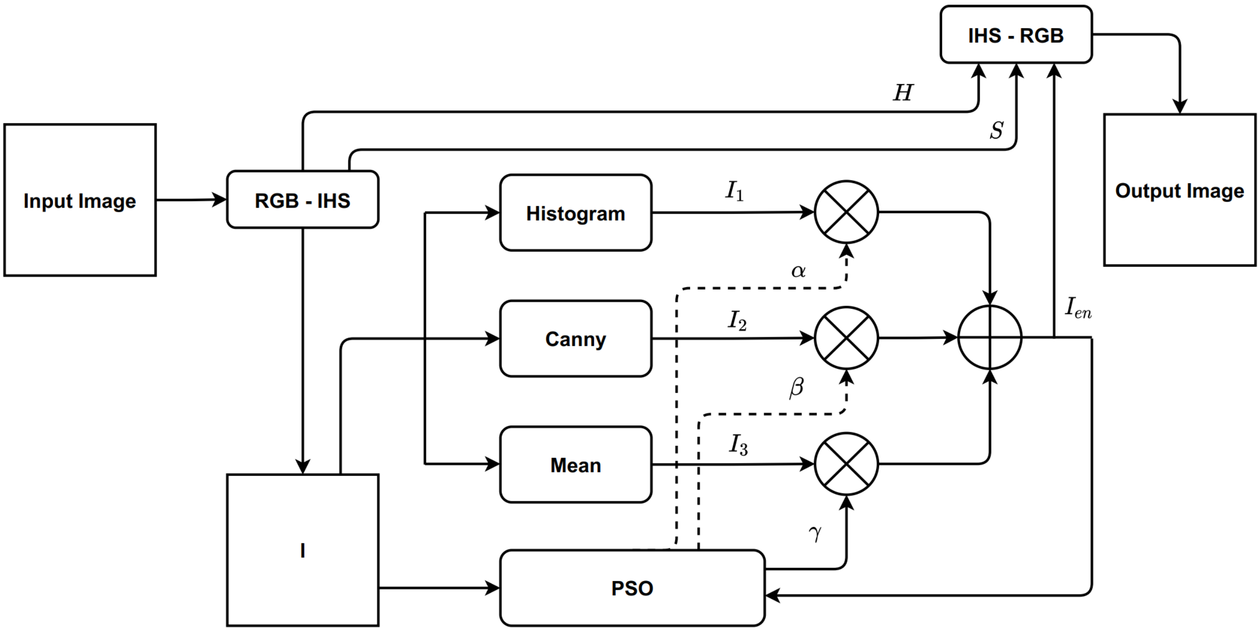

FIGURE 2. The scheme of the algorithm of medical image fusion PSOIE.

- Step 1: Convert image input image from RGB color space to HIS color space to get I, H, S.
- Step 2: Generate images I_{hist} (histogram equalization image) I_{can} (candy edge image) and I_{median} (median image) of I, using histogram equalization, candy edge detection and median filtering:

$$I_{hist} = histEq\left(I\right) \tag{3}$$

$$I_{can} = candy\left(I\right) \tag{4}$$

$$I_{median} = median\left(I\right) \tag{5}$$

- Step 3: Generate I_{en} by following formula:

$$I_{en} = \alpha * I_{hist} + \beta * I_{can} + \gamma * I_{median} \tag{6}$$

  The parameters α, β, γ are found, using an algorithm PSO with the optimization of objective function as follows:

$$J = \left(\frac{\sigma^2}{\mu}\right)\left(H_2 - H_1\right) \tag{7}$$

  Where, σ^2 and μ are variance and mean intensity value for the enhanced intensity channel. H_1 is entropy of I_{new} and H_2 is entropy of I_{en}.
- Step 3: Convert the components I_{en}, H, S from color space HIS to color space RGB to get the output fused image.

In this algorithm, we proposed some improvements:

- A schema of image enhancement parameter optimization.
- Combining some image transformations: histogram equalization, edge detection candy and median filter for creating enhanced image.
- The parameters α, β, γ are found by optimizing function J using the PSO algorithm.

4. **Experiments.** Recent methods that used for comparing with proposed methods includes: Ying [27] and the SGHIE [23]. To assess image quality, we use the measures: Entropy và Sharp [25]. Due to the scope of the paper, we illustrate some experimental results in Figure 3 and evaluation in Table 1 (image quality is directly proportional to the index values). From Figure 3, visually, it can be seen:

- All three methods Ying and SGHIE and suggested for enhanced image brighter than original image.
- The two methods Ying and SGHIE, although helping to make the image brighter than the original image, neither method is superior to the other. For images 1, 2, the resulting Ying method image is more contrasting than the SGHIE method result image. However, for images 3, the resulting image of Ying method has poor contrast compared with the resulting image of SGHIE method.
- The proposed method shows that the contrast is better than the two methods Ying and SGHIE. Especially, with the proposed method, the objects on the enhanced image are distinguished much better than the two compared methods.

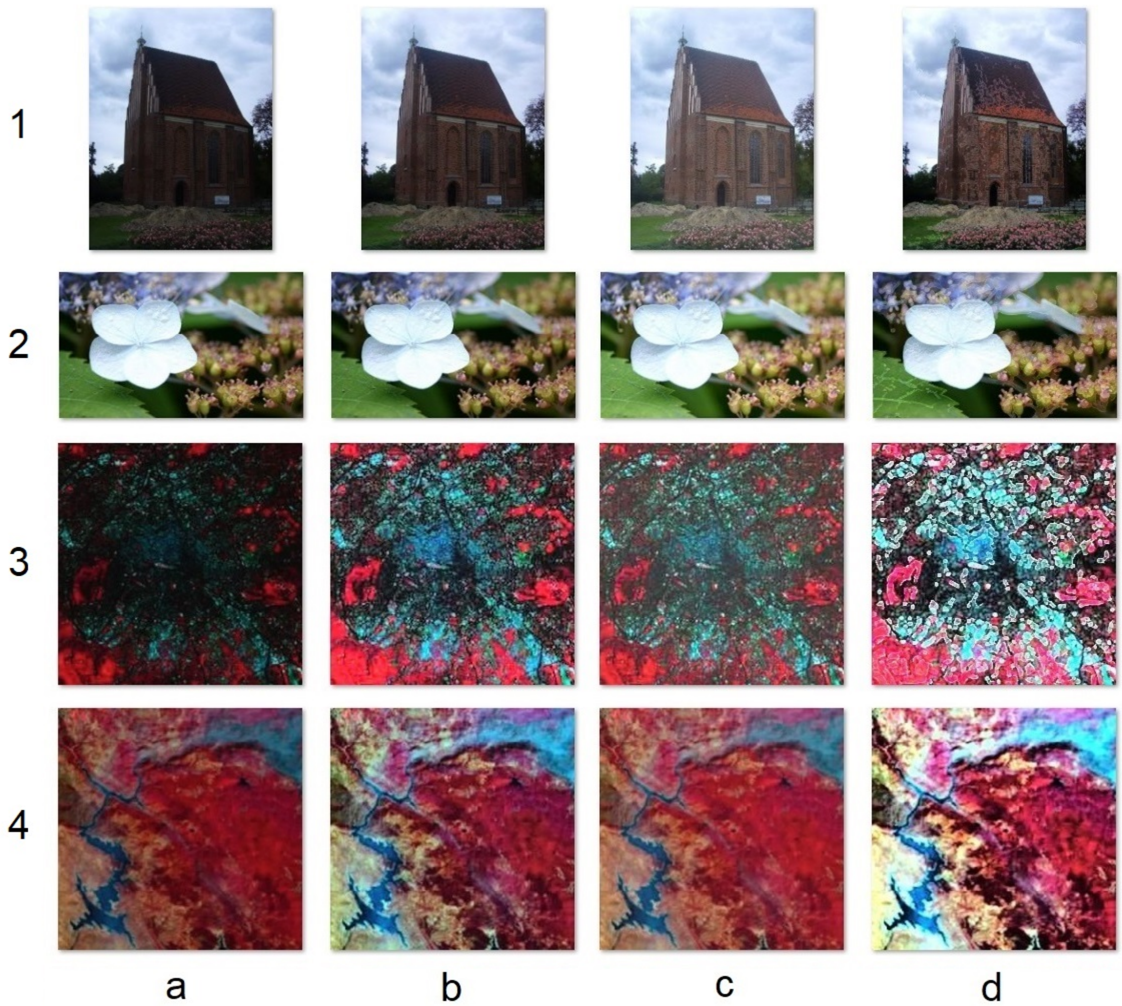

FIGURE 3. Some experimental image: a-input images, b-SGHIE images, c-Ying images, d-PSOIE images.

From the table in figure 4, it shows:

- During the tests, the values of the Entropy and Sharp indicators changed positions between tests. This indicates a lack of stability in the enhancement effect of the methods SGHIE and Ying.
- Meanwhile, the index values in the tests of the proposed method are higher than those of the two methods SGHIE and Ying. This shows that the proposed method gives better enhanced image quality than the methods SGHIE and Ying.

Image	Index	SGHIE	Ying	PSOIE
P1	Entropy	7.1630	7.2276	**7.5993**
	Sharp	0.0963	0.1046	**0.2206**
P2	Entropy	6.5137	6.5995	**7.0420**
	Sharp	0.1109	0.0801	**0.4372**
P3	Entropy	7.1552	6.9705	**7.7787**
	Sharp	0.0543	0.0427	**0.0856**
P4	Entropy	6.5006	6.6742	**6.9426**
	Sharp	0.0659	0.0564	**0.3207**
P5	Entropy	7.1271	6.9791	**7.5589**
	Sharp	0.0705	0.0657	**0.1727**
P6	Entropy	7.2342	7.3234	**7.6751**
	Sharp	0.0528	0.0672	**0.1022**
P7	Entropy	7.7987	7.8247	**7.8415**
	Sharp	0.0196	0.0220	**0.0547**

FIGURE 4. Compare the quality of enhanced images based on measurements.

5. **Conclusions.** This paper introduces the new algorithm of enhancing images which is based on parameter optimization. This algorithm is PSOIE with purpose is enhancing the quality of the input image. The results getted by the experiments show that the ouput images of the proposed algorithm are better than some others recent methods about brightness, edge enhancement, image sharpening and noise reduction. In future works, we intend to continue applying the parameter optimization to other problems of image processing

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