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Image Enhancement Based On Bee Colony Algorithm

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Abstract: High quality images are needed in the processing of digital images and along with the growth of internet's bandwidth the image transimition can be quickly and easily to perform. Image quality that is acquired from various sources can be damaged or distorted for various reasons, therefore, an enchancement model is needed to improve the image quality. This research focuses on implementing an image enhancement method based on bee colony algorithm. Integrating adaptable bee colony algorithm and fuzzy set, this study show implementation of fuzzy entropy into the adaptable fuzzy entropy and uses artificial beef colony algorithm to perform the contrast enhancement under the maximum entropy criterion. The experimental result shows that the method can be maximized the dynamic range compression of the image, enhances the image attributes of the image, enhances the image details, maximized some color fidelity capacity and effectively outperforms the performance of the traditional image enhancement methods.

Key words: Image enhancement, bee colony algorithm, domain spatial transformation, image processing, histogram enhancement, histogram equalization

INTRODUCTION

Image enhancement is mainly aimed to improve the visual quality of image. Image enhancement selectively highlights the interesting characteristics or suppresses (covers) some unnecessary characteristics in the image to make the image match visual response characteristics and get a more practical image or transform into an image more suitable for human or machine to perform analytical processing by adding some information or changing data. Image enhancement doesn't analyze the reasons to image degradation and the processed image may not be closed to the original image (Binaee and Hasanzadeh, 2014; Chaira, 2012).

After long intensive research, image enhancement method has made significant progress and has established several theoretical algorithms by now. According to the different spaces where the enhancements are located, it can be divided into algorithms based on spatial domains and algorithms based on frequency domain (Lei and Fan, 2014). The former algorithm directly operates on the grayscale image while the latter makes certain corrections to the image transformation coefficient value in a particular image transformation domain which is a direct improvement algorithm. It should be pointed out that this traditional image enhancement technology does not assume image helplessness on the contrary, only changes the contrast or suppresses the noise of the whole image. This weakens the detail of the image in the suppression of noise it definitely causes serious negative effects and has certain limitations (Chyan and Sumarta, 2014). So far, image enhancement based on fuzzy theory has achieved significant results and the main advantage of fuzzy image enhancement is that it can store image detail (Chyan and Sumarta, 2015). Selection of parameters such as membership and operator enhancement in image fuzzy enhancement play an important role in improving effect while artificial bee colony algorithm has the advantage of simple calculation, ease to be realized and few control parameters. Considering the parallelism of the artificial bees colony algorithm, as a function of the bee colony's fitness algorithm, the new definition of fuzzy entropy proposed in this study has good resistance, introduces loyalty and improves algorithm stability and ability to retain details.

This research will structure and introduce the basic idea, the differences and application characteristics of the common methods of image enhancement. Then, it integrates and conduct the adaptable bee colony algorithm and fuzzy sets and integrate the fuzzy entropy into the adaptive fuzzy enhancement of image, so as to realize the self-adaptive parameter selection. Then, it will raises a new definition of fuzzy entropy based on the indicial response of information increase and it realizes the self-adaptive contrast enhancement of image by using adaptable bee colony algorithm in the maximum entropy criterion. Then in the end, it realizes the adaptive fuzzy enhancement of image through the simulation experiments.

Literature review

Image enhancement: Image enhancement is a method to highlight some information in an image and weaken or get rid of some unnecessary information according to some specific requirements. It purpose is to enhance the clarity and contrast of image in certain specific applications to improve the image quality and make the processed results more consistent with human visual sensory system or easier to be recognized by machines (Balasubramaniam and Ananthi, 2014). The current common-used of enhancement technique is divided into technique based on spatial domain and technique based on transformation domain. The first method directly works in the space of the image while the second method works in the transformation domain of the image. The common-used transformation space is the frequency domain space, namely the Fourier transform. The enhancement technique based on spatial domain consist: the grayscale transformation to enhance image through per pixel location, the histogram transformation to change the image contrast globally or locally and the spatial transformation to process the neighborhood pixels of image through template or masking (Chaudhry *et al*., 2013). Figure 1 demonstrates two common transformation functions of spatial-domain image enhancement.

The enhancement of frequency domain space is realized through different frequency components in the image. The image frequency spectrum gives global characteristics of the image, therefore, the frequency-domain enhancement is not implemented per pixel and it is not as direct as the spatial-domain enhancement. The frequency-domain enhancement is realized through the filter and the frequency filtered by different filters and the reserved frequency differ from each other, therefore, it can get different enhancement effects.

Digital image processing: A simple understanding of image processing is the manipulation and analysis of an image information by a computer. While the definition of image information here is a visual image in two dimensions. Any operation to repair, analyze or alter an image is called image processing.

The basic concept of the system of image processing is derived from the ability of the human vision to be connected to the human brain. In its history, image processing has been applied in various forms with a considerable degree of success. Like other branches of science, image processing involves various merges of branches of science such as optics, electronics, mathematics, photography and computer technology.

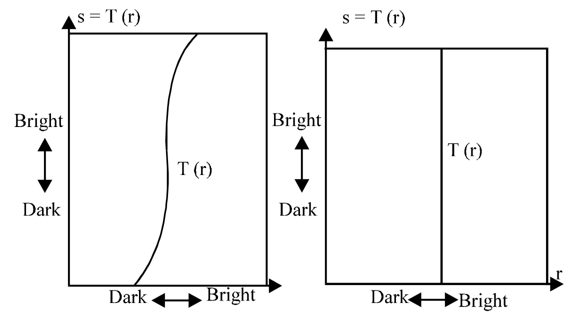

Fig. 1: Transformation functions of contrast enhancement

In general, the purpose of image processing is to transform or analyze an image, so that, new information about the image is made more clear. There are many ways that can be applied in an image processing operation, mostly in optical form. Various fields have been widely used applications from image processing in the field of commercial, industrial and medical. Even the military field has been using the development of this digital image processing world. In general, the purpose of image processing is to transform or analyze an image, so that, new information about the image is made more clear. There are many ways that can be applied in an image processing operation.

There are no clear-cut boundaries in the continuum from image processing at one end to computer vision at the other. However, one useful paradigm is to consider 3 types of computerized processes in this continuum: low, mid and high-level processes. Low-level processes involve primitive operations such as image preprocessing to reduce noise, contrast enhancement and image sharpening. A low-level process is characterized by the fact that both its inputs and outputs are images. Mid-level processing on images involves tasks such as segmentation (partitioning an image into regions or objects), description of those objects to reduce them to a form suitable for computer processing and classification (recognition) of individual objects. A mid-level process is characterized by the fact that its inputs generally are images but its outputs are attributes extracted from those images (e.g., edges, contours and the identity of individual objects). Finally, higher-level processing involves “making sense” of an ensemble of recognized objects as in image analysis and at the far end of the continuum, performing the cognitive functions normally associated with vision.

Image histogram: The histogram is a graph showing the frequency of occurrence of each color gradient value. When depicted in cartesian coordinates, the X axis (abscissa) indicates the color level and Y axis (ordinate) indicating the frequency of appearance of the color in an

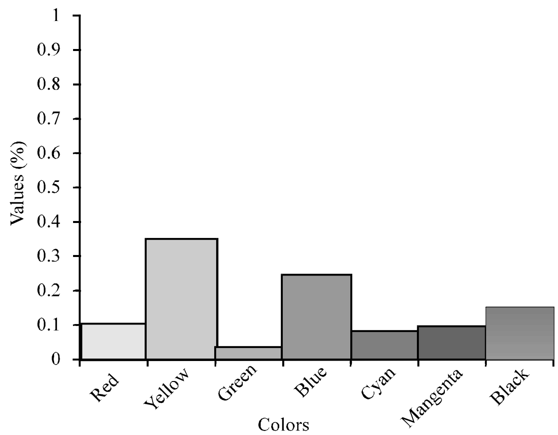

Fig. 2: Image histogram

image. The color histogram is the most widely used color feature. Color histograms are very effective in characterizing the global distribution of colors in a digital image. Color composition is one of the features that can be used in image retrieval system. The color composition can be represented in the form of a histogram. The color histogram represents the distribution of the number of pixels for each color intensity in the image. To define the color histogram, the colors are quantized into several discrete levels according to the color space model used eg RGB, YIV and other color space models where each color space has its own characteristics then for each level the quantization results of the color was calculated the number of pixels the corresponding value shown in Fig. 2.

Calculate the image histogram: Commonly used colors are RGB (Red, Green, Blue). If each color is discriminated to m interval then the total discrete amount is m_3. With a histogram can be searched image that has similarity of color composition. Measurement of similarity level is done by calculating the distance between histogram. If G = $\{g_1, g_2, g_3, ..., g_n\}$ and H = $\{h_1, h_2, ..., h_n\}$ is the color histogram of two images where gi and hi are the number of pixels at the i-level of the two histograms and n is the number of levels for each histogram, the distance (d) between two histograms can be expressed in Manhattan distance as shown in Eq. 1:

$$d = \sum_{i=1}^{N} |g_i - h_i| \tag{1}$$

Image retrieval steps based on the color histogram feature are as follows:

- Create an image matrix
- Create a histogram
- Calculate the distance of the histogram
- Finding the image with the smallest histogram distance
- Displays the image with the smallest histogram distance

An image with a smaller distance value is considered to have a similarity level of higher or more similar color compositions compared to images with larger distance values. For example, there is a 3×3 pixel image with RGB value as follows:

(1, 1, 1) (1, 2, 0) (1, 2, 0)
(1, 1, 0) (2, 1, 0) (2, 3, 1)
(3, 2, 1) (2, 2, 1) (2, 1, 0)

Color features are the most widely used feature in the image retrieval system. Many of them use the image color histogram. A color histogram between two images can be calculated where the image with the smallest distance is the solution. For example, there are two images with a quantized four color histogram as follows:

HA = {20, 30, 10, 40%}
HB = {10, 10, 50, 30%}

To calculate the distance of the histogram between the two images can be used the formula as in the following Eq. 2:

$$d(A, B) = \sum_{j=1}^{n} |H_j^A - H_j^B| \tag{2}$$

Histogram equalization: A histogram is defined as the statistical probability distribution of each gray level in a digital image. Histogram Equalization (HE) is a very popular technique for image contrast enhancement (Kim and Paik, 2008; Sengee and Choi, 2008). The basic concept of the histogram equalization is by strecth the histogram, so, the pixel difference becomes larger or with other words information becomes stronger, so, the eye can capture the information delivered. The contrast image is determined by the dynamic range which is defined as the ratio between the brightest part and darkest intensity of pixels. The histogram provides information for the contrast and the overall intensity of the distribution from an image. Suppose the input image f(x, y) consists of a discrete gray level in the dynamic range (0, L-1) then the transformation function C(rk) can be defined as Eq. 1 (Shih, 2010):

$$S_k = T(r_k) = (L-1)\sum_{j=0}^{k} p_r(r_j) = \frac{L-1}{MN}\sum_{j=0}^{k} n_j \tag{3}$$

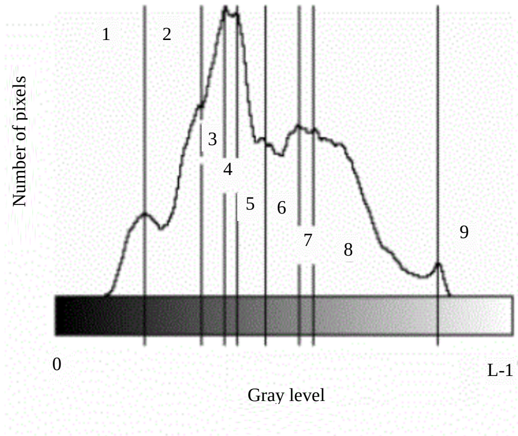

Fig. 3: Histogram graphic on HE

For equations of histogram equalization transformation in digital images:

M×N = Variable denotes the total number of pixels
L = Number of gray levels
() r_j p_r = The number of pixels in the input image with the intensity of the value of r_j

Range of input values and the gray output is in the range of 0.1.2, ..., L-1. Then, the histogram equalization transforms the value of the input value k r (where, k = 0.1, 2, ..., L-1) to the output value k S. As can in Fig. 3 (Ravichandran and Magudeeswaran, 2012).

Histogram equalization is a method in image processing that improves image contrast in general, especially when used image data is represented by values near the contrast. Through this adjustment, the intensity of the image can be distributed on the histogram better. This allows for contrast areas local to get a higher contrast without affecting global contrast. This method is very useful with backgrounds and foregrounds scene which are both bright or both dark. In particular, this method will provides a better view of bone structure in x-ray images in the biomedical world, yielding clear picture detail (Agarwal, 2011).

MATERIALS AND METHODS

The honey-collecting process of the bee (namely to find high-quality honey sources) is similar to the process to search the optimal solution to the problem to be optimized in the evolutionary computation. The honey collection is realized through the communication, the transformation and the collaboration among different bees. The process for the bee colony to collect honey includes three basic parts and two basic behaviors. The three parts are foods, employed bees and unemployed bees and the two behaviors are to recruit and abandon certain foods. The essence of artificial bee colonyalgorithm is to search optimal solution through the random but targeted evolution on the group formed by the candidate solutions. In every circulation, the numbers of leaders and followers are the same and there is only one or no scouter. The solution evolution is completed by the above-mentioned three kinds of bees: employed bee conducts local search in the neighborhood domain of its corresponding foods and updates its foods when finding new foods optimal to the current foods; according to the food information provided by the employed bee, the follower chooses the food through certain selection method; makes local search near the selected food sources; informs corresponding employed bee to the current foods and updates the foods when finding more excellent new foods. When the follower chooses the foods, excellent foods (solutions with high fitness) can attract more followers. With several searches in the neighborhood domain and these foods have more evolution opportunities. In the stagnation of the termination solution of scouter, namely when the solution evolution stagnates, the un-employed bee abandons the current foods and becomes a scouter. Then it randomly searches and generates a feasible solution as a new food and conveys the relevant information to the employed bee. Through the collaboration of the above-mentioned three kinds of bees, ABC algorithm gradually converges and obtains the optimal solution or approximate optimal solution in the feasible solution space:

$$\min\{f(x): x \in S \subset R^d\}$$

First step inisialize ABC algorithm randomize early population with SN solution as Eq. 4:

$$x_{ij} = x_j^{min} + rand(0,1) \times (x_j^{max} - x_j^{min}) \quad (4)$$
$$i = 1, 2, ..., SN, \; j = 1, 2, ..., d$$

Then researcher bees search for suitable food, randomly select other bees as neighbors and randomly select the dimensions as a search direction guide. The search process is done according to the Eq. 5 and 6:

$$v = r \times (x_{ij} - xneighbour.j) \quad (5)$$

$$x_{ii}^{new} = x_{ii} + \nu \quad (6)$$

Then transformation to border value according to Eq. 7:

$$x_{ii}^{new} = \begin{cases} x_{ij}^{min}, x_{ij}^{new} < x_{ij}^{min} \\ x_{ij}^{max}, x_{ij}^{new} > x_{ij}^{max} \end{cases} \quad (7)$$

If the quality (suitability) of the food sought (solution) X_i^{new} is better than the present food, replace the new food with the present food if not leave the food position unchanged. After the search of the entire worker bee is complete, return to the hive and share the food information on the unemployed bee and then the follower decide the return rate of each food according to the information obtained and collect the honey through random selection. The return rate is expressed by the fitness value of the solution in Eq. 8 and 9:

$$\text{fit} = \begin{cases} \frac{1}{1+f_i}, f_i > 0 \\ 1+|f_i|, f_i \le 0 \end{cases} \quad (8)$$

$$p_i = \frac{\text{fit}_i}{\sum_{j=1}^{SN} \text{fit}_j} \quad (9)$$

Where:
f_i = The function value of the i-th solution
fit_i = His the appropriate fitness value
SN = The Number of Solutions

Obviously, based on the roulette wheels selection, good food can attract more followers and have a higher chance of evolution and can accelerate the convergence rate of the algorithm. After his followers chose food, search the food environment domain according to Eq. 7 and 8, adjust the food according to Eq. 9, performing greedy selections to the newly searched position and maintain a better solution (Aydin *et al*., 2014; Mohammadi and Abadeh, 2014). If the food is stagnant in a certain position longer than the predetermined time limit, it is indicates that this solution is stuck in the optimal local and appropriate solution honeybees become a booster and leave food and produce randomly new solution (solution) to replace the abandoned food (solution) in Space S in accordance with Eq. 6. The limit here is the boundary parameter to judge whether a particular solution exits from current stagnation status (Kalayci and Gupta, 2013). The flowchart of bee colony algorithm is shown as Fig. 4.

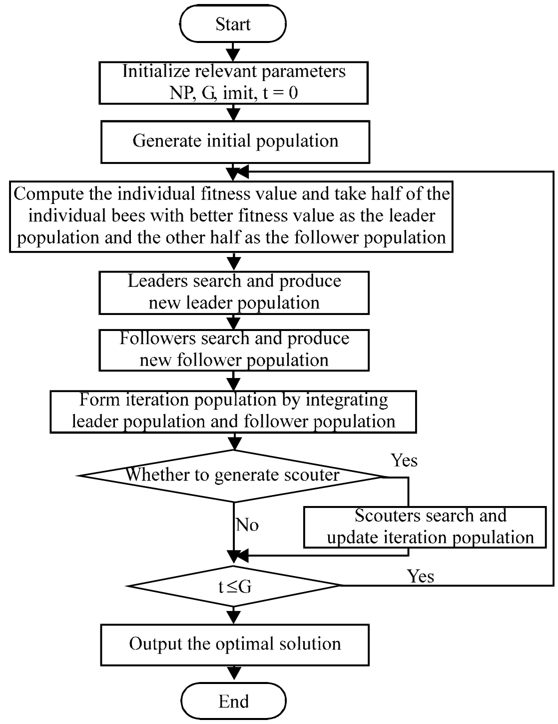

Fig. 4: Bee colony algorithm flowchart

RESULTS AND DISCUSSION

The self-adaptive fuzzy enhancement algorithm proposed in this study is realized under the maximum fuzzy entropy criterion, therefore, the selection of optimal fuzzy parameters is the parameter optimization under the maximum fuzzy entropy in essence and it can directly use fuzzy entropy as fitness function and it adopts the new definition of fuzzy entropy proposed in this study. In order to reduce as much running time as possible, it stabilizes when the population size is 30 and the termination algebra is 100. The initial value of fuzzy parameter in bee colony algorithm is generated randomly. Therefore, we choose the termination algebra of 100. Figure 5 is the contrast chart between the original image and the algorithm of this study. Table 1 is the average value, standard deviation and entropy of original image, ant colony algorithm and ABC algorithm. Figure 6 is the histogram of the average value, standard deviation and entropy of original image and algorithm of this study.

Figure 6 shows histogram from average value, standad deviation and entropy from original image and image after enhancement proses. The average value increases after histogram equalization, demonstrating that the brightness is high and the standard deviation is small and reflecting that the equalization effect is not good enough. It can be seen from the experimental data that

Table 1: Average value, standar deviation and entropy of original image, ant colony and ABC algorithm

Variables	Average	Standar deviation	Entropy
Original image	050.2849	43.7312	7.3471
Ant colony	151.4758	82.8231	6.8263
Image enhancement	121.2631	51.8427	8.3489

Fig. 5: Image before processing (top) dan image after enhancement (bottom)

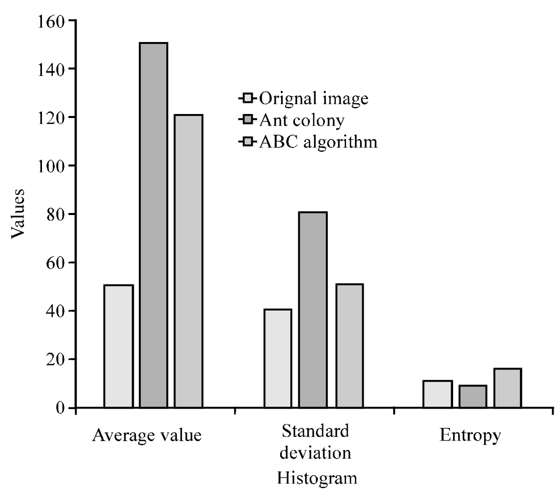

Fig. 6: Histogram for average, deviation standard and entropy value

average value and mean square deviation increase after being processed by ant colony algorithm, however, the entropy decreases, the brightness increases and the definition becomes bad. It can be seen that after ant colony process, obvious color distortion appears and definition decreases. The adaptable bee colony algorithm has better dynamic range compression and definition enhancement as well as color fidelity ability. And we can find that it can enhance the dynamic range compression of the image, the visual effects of the image and the image details and has certain color fidelity capacity.

CONCLUSION

Image enhancement is a basic technique of digital image processing and can effectively improve global or local image characteristics. By using bee colony algorithm optimization and parallelization capacities of bee colony algorithms globally, this study proposes a new definition of fuzzy entropy as a fitness function of the Colony bee algorithm which automatically searches for optimal fuzzy parameters, improves algorithm stability and ability to maintain detail, enhances fuzzy self-adaptive have better color fidelity capacity and improve image quality for real time application.

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