The adaptive genetic algorithm graphics design based on fuzzy entropy thresholding method

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Abstract

In today's society with rapid development of science and technology, the computer figure image design can be widely used in various industries. The quality of graphics design plays a very important role in the film, television, advertising, exhibition, art, electronic play and so on. With the development of computer information technology, the design of the graphics technology will progress. This paper prompts a adaptive genetic algorithm graphics design method based on fuzzy entropy thresholding which can improve the quality of digital graph. The experiment shows that the AGA-FET method proposed in this paper overcomes such defects of the traditional FET method as low computation efficiency of the exhaust algorithm and poor adaptability to the various images resulting from presetting the bandwidth of membership function.

Keywords: blurry images; adaptive genetic algorithm; image thresholds; fuzzy entropy thresholding method.

1 Introduction

For seeding in visual communication of the new generation of new type, digital art completely penetration into our daily lives, as a current technique for flow line and a kind of art, many young people are hot in the attempt, use this approach to release their own imagination, table by oneself mood, can say is both simple and complex. Computer graphics design and visual communication design, the solution is not the design division Their hands, and let their big brain thinking dimension with elastic, source not broken inspiration comes from their release his banned GU want to like, don't be trapped by the so-called skill box To live, not to be knowledge of shadow ring now, create the super natural, unconscious, the conventional special work, is to calculate machine figure charts as the unique design and visual communication design. Of design in visual communication as the name, righteousness, is through the visual communication of each kind of information a straight design, each item through his shape, color, size, light jersey, even in some of his little detail, USES, has its own characteristics, such as visual character, through the message content, and then by the individual to the group, group to group body spread to spread to his design purpose, he can through the newspaper, television, miscellaneous Tzu chi and other media in not with the identity of the composition, conveys his own design concept, and sharing of the masses. I have used the visual communication design as one kind of method of dimensional expression on the hand, he is in the presence of words and images, the two people at the same time, in the face of structural phase complementary filling phase offset each other, will each other's advantages of lining, so the visual communication in the number of operators (especially the text symbols) to carry on the design, be sure to do may double optimization, its advantages, play all kinds of symbols to convey through integration, will introduce his multifaceted.

Image segmentation is to distinguish objects from background in the image using the proper thresholds. Among the various approaches to determine the thresholds, the fuzzy entropy thresholding (FET) method [1-4] has been widely used. But the traditional FET method is time consuming and it has poor adaptability to the various images because it requires presetting the bandwidth of membership function and involves exhaust algorithm in finding the optimal threshold [5]. To overcome the drawbacks of the traditional FET method, the genetic algorithm (GA) has been introduced into the FET method to [6, 7]. As a probabilistic and heuristic search method based on biology evolution theory and genetics mechanism, GA has a high search efficiency and good global optimization performance. However, the standard GA generates the initial population randomly and fixes crossing probability and mutation probability throughout the evolution process, which will lead to pre-maturity and low convergence speed [8].

Machine vision is widely used in modern mechanical systems, such as semiconductor end-package equipments, surface mounting machines and mobile robots et al. But the images acquired by the CCD camera in these equipments are generally influenced by such factors as vibration of the mechanical structure, quality and resolution of cameras and illumination variations et al. These disadvantageous factors usually will lead to the fuzziness of the images and make it difficult to realize the accurate edge detection of the blurry images.

2 AGA graphics design based FET method

2.1 ENCODING AND FITNESS FUNCTION

Let $x_{i,j}$ be the gray-level value of the image X of size $M\times N$ at pixel position (i,j). According to the fuzzy subset theory, the image X can be represented using the following fuzzy matrix:

$$X=[\mu(x_{i,j})]_{M\times N} \qquad 1\le i\le M;1\le j\le N\ , \tag{1}$$

where $\mu(x_{i,j})$ $(0\le\mu(x_{i,j})\le 1)$ is the membership degree of $f_{i,j}$. The membership degree $\mu(x_{i,j})$ and its Shannon function $S(\mu(x_{i,j}))$ are defined as [5-8]:

$$\mu(x_{i,j})=\begin{cases}0 & x_{i,j}<T_0\\ \dfrac{(x_{i,j}-T_0)^2}{(T-T_0)(T_1-T_0)} & T_0\le x_{i,j}\le T_1\\ 1-\dfrac{(x_{i,j}-T_1)^2}{(T_1-T_0)(T_1-T_0)} & T\le x_{i,j}\le T_1\\ 1 & x_{i,j}>T_1\end{cases}, \qquad (2)$$

$$S(\mu(x_{i,j}))=-\mu(x_{i,j})\ln(\mu(x_{i,j})) - (1-\mu(x_{i,j}))\ln(1-\mu(x_{i,j})). \qquad (3)$$

The interval between T_0 and T_1 constitutes the fuzzy region. Let $\Delta T=T_1-T_0$ and $T=(T_0+T_1)/2$. The fuzzy entropy $E(T,\Delta T)$ of image X is defined as:

$$E(T,\Delta T)=\frac{1}{MN\ln 2}\sum_{i=1}^{M}\sum_{j=1}^{N}Sn(\mu_{ij}(x_{ij}))\,. \qquad (4)$$

Let T and ΔT be encoded as 8 bit variables in the binary mode. The single chromosome is composed of the two variables. To get the threshold using the maximum fuzzy entropy principle, the fuzzy entropy (objective function) will be mapped into the fitness function as follows:

$$f(T,\Delta T)=E(T,\Delta T)\,. \qquad (5)$$

The standard GA generates initial population randomly. This method tends to produce a narrow search space, which is disadvantageous to the acquisition of the global optimal solution. To improve the convergence characteristics of GA, the initial population is generated using uniform partition based generation method. This method evenly divides the range of optimized parameters into regions with their number equal to population scale Gs. In every small region, an individual will be generated randomly. This method can quicken the convergence speed and increase the possibility of converging to global optimal solution.

The proportion selection and sort selection will be generally used by the standard GA. For proportion selection, the pre-maturity is easy to occur when the evolution process is dominated by few chromosomes with much higher fitness in the population. When there exists some chromosomes with close fitness, the GA intends to search randomly and its convergence speed will be reduced. The sort selection can solve these problems, but it deflects the individual fitness too far. Combining the two selection methods, the mixed selection method is adopted. This method first sorts the individual fitness in descending order and then uses proportion selection to find the individuals until their number reaches the population scale.

2.2 ADAPTIVE CROSSOVER AND MUTATION

Crossover probability P_c and mutation probability P_m are fixed in the standard GA. But they should vary with the distribution of individuals in the population. In the early evolutionary period, the individuals are distributed dispersedly and so P_c should take higher value to realize the combination of effective modes while P_m should take a small value to prevent the damage of effective gene. In the later evolutionary period, the individuals tend to have close fitness and so P_c should be reduced while P_m should be increased to avoid the inbreeding between two individuals and preserve the diversity of the population. Based on the above analysis, the crossover probability P_c^t at t-th generation will be defined as:

$$P_c^t=\begin{cases}P_{\max}-\dfrac{(P_{\max}-P_{\text{temp}})(f_b^t-f_{\text{avg}}^t)}{f_{\max}^t-f_{\text{avg}}^t} & f_b^t\ge f_{\text{avg}}^t\\ P_{\max} & f_b^t<f_{\text{avg}}^t\end{cases}, \qquad (6)$$

Where:

$$P_{\text{temp}}=\begin{cases}P_{\min} & P_{\max}e^{-\frac{t}{T_l}}\le P_{\min}\\ P_{\max}e^{-\frac{t}{T_l}} & P_{\max}e^{-\frac{t}{T_l}}>P_{\min}\end{cases}, \qquad (7)$$

where $P_{\max}$ and $P_{\min}$ are the maximum crossover probability and the minimum one, T_l be the maximum iteration times, f_b^t be the bigger fitness of two individuals chosen for crossover operation at t-th generation, and f_{avg}^t denote the maximum fitness and average fitness of the population at t-th generation. Similarly, the mutation probability P_m^t at t-th generation will be defined as:

$$P_m^t=\begin{cases}P'_{\max}-\dfrac{(P'_{\max}-P'_{\text{temp}})(f_k^t-f_{\text{avg}}^t)}{f_{\max}^t-f_{\text{avg}}^t} & f_k^t\ge f_{\text{avg}}^t\\ P'_{\max} & f_k^t<f_{\text{avg}}^t\end{cases}, \qquad (8)$$

Where:

$$P'_{\text{temp}}=\begin{cases}P'_{\min} & P'_{\max}(1-e^{-\frac{t}{T_l}})\le P'_{\min}\\ P'_{\max}(1-e^{-\frac{t}{T_l}}) & P'_{\max}(1-e^{-\frac{t}{T_l}})>P'_{\min}\end{cases}, \qquad (9)$$

where $P'_{\max}$ and $P'_{\min}$ are the maximum mutation probability and the minimum one, f_k^t be fitness of the individual chosen for mutation operation at t-th generation.

There are such regenerating methods as E method, G method, B method and N method. E method preserves only one parental individual. G method regenerates partial individuals in a certain proportion. B method regenerates the new individuals by choosing the excellent ones simultaneously among parents and children. N method completely replaces the previous generation. Because these methods can not achieve both excellent global searching capability and excellent convergence speed, the updating strategy based on preference between two generations is proposed. In the new updating strategy, the fitness of all the individuals in the parent generation and child generation is first separately sorted in the descending order. Then the fitness of the individual in the sorted parent generation is compared with that of the corresponding individual in the child generation. The individual with greater fitness will be preserved in the new generation. The new updating strategy preserves the excellent individuals between the two generations, which is conducive to the improvement of both global searching capability and convergence speed.

3 The experiments and analysis

Images are often corrupted by impulse noise in the process of transmission over noisy communication channels or recording by noisy sensors. The median filter, a kind of effective nonlinear filter, has been widely used for removing impulse noise because of its superior performance in noise suppression and edge preservation in comparison with the linear filters. However, the AGA-FET is implemented uniformly across the entire image without taking account of whether a pixel is corrupted or not. Inevitably, the AGA-FET will modify both noise pixels and undisturbed good pixels, thus causing the blurring or furthermore loss of fine details in the image.

To prevent the alteration of good pixels, switching-based filters realized using thresholding operations have been studied recently. In the switching filtering schemes, the noise detector is firstly used to classify the pixels in the image as the corrupted pixels or noise-free pixels and then filtering is activated for the detected corrupted pixels. At a relatively low noise ratio, these filters can perform better than the AGA-FET by removing impulse noise while preserving the fine details very well. However, they tend to damage the details or retain too much impulse noise in the image at a high noise ratio.

To evaluate the performance of the AGA-based FET method based on (AGA-FET), the adaptive FET method (AFET) [3] and the GA based FET method (GA- FET) [4] are adopted to make comparisons. The welded image with the linear defects and the welded image with the circular defects are segmented by the three methods. The runtime of these methods and the optimal threshold are listed in Table 1. In the AGA-FET method $P_{\max} = 0.8$, , $P'_{\max} = 0.1$, $P'_{\min} = 0.01$, $T_l = 40$ and $G_s = 20$. In the GA-FET method, $P_c = 0.8$, $P_m = 0.1$. Here it must be noted that the runtime means the average time for every method to implement for 30 times on a personal computer equipped with 851-MHz CPU and 256-M RAM memory. The optimal threshold is the average value of all the optimal thresholds for 30 runs.

From these experimental results, it can be seen that the AGA-FET has similar computation time to the GA-FET and it has by far less runtime than that of AFET. On the other hand, AFET and GA-FET get the unreasonable optimal thresholds so that the two welded images, to some extent, suffer from false segmentation.

It can be seen from TABLE I that the non-optimized algorithm runs slightly slower than the Sobel operator while it is implemented more quickly than the GA-FET algorithm and Canny operator. The optimized AGA-FET algorithm has the highest computation efficiency than other algorithms. The comparison between the run time for the chip image and that for the model image can demonstrate that the advantage of AGA-FET algorithm over other algorithms in the computation efficiency is more obvious with the increasing image size.

TABLE 1 The run time for five edge detection algorithms

Algorithm	**welded image with the linear defects**		**welded image with the circular defects**	
	threshold	*runtime(ms)*	*threshold*	*runtime(ms)*
AFET	72	300	112	280
GA-FET	57	100	130	90
AGA -FET	85	117	95	108

The visual comparisons of calculating speed for a same picture using AFET, GA-FET and AGA-FET is shown in figure 1.

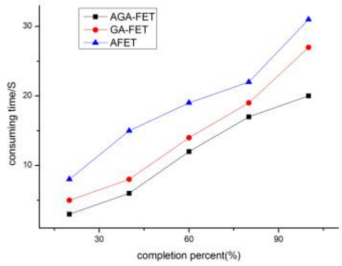

FIGURE 1 Comparisons of calculating speed for a same picture using AFET, GA-FET and AGA-FET

The result shows that the average disposal speed of AGA-FET method is faster than AFET and GA-FET.

The visual comparisons of loading speed for a same picture using AFET, GA-FET and AGA-FET is shown in figure 2. In the same consuming time, the AGA-FET loading percent is more than AFET, GA-FET. We can notice that the loading percent does not make linear change to the consuming time.

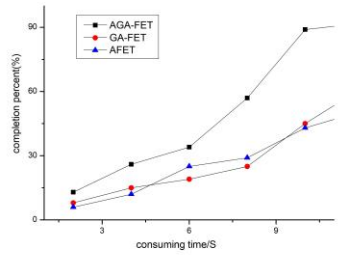

FIGURE 2 Comparisons of loading speed for a same picture using AFET, GA-FET and AGA-FET

All the five algorithms programmed in VC++ language are run on the Intel Pentium III computer (CPU: 477MHz; RAM: 120M). For each algorithm, it is implemented for ten times and the average time spent for the ten implementations is used as the run time. The visual comparisons of impulse noise for a same picture using AFET, GA-FET and AGA-FET is shown in figure 4. In the same consuming time, the AGA-FET impulse noise is less than AFET, GA-FET. To restore the highly corrupted image effectively, the adaptive genetic algorithm graphics design based on fuzzy entropy thresholding method (AGA-FET) is proposed in this letter. Different from many well known decision-based filters, the proposed filter uses the progressive noise detector to identify the corrupted pixels and adopts the adaptive weighted mean filter to remove the detected impulse noises. By combining this novel noise detector with the distinctive mean filter, the adaptive genetic algorithm graphics design based on fuzzy entropy thresholding method (AGA-FET) achieves significantly better restoration performance than many other decision-based filters at the various noise ratios, especially when the image is highly corrupted by impulse noise. The comparison between the run time for the chip image and that for the model image can demonstrate that the advantage of AGA-FED algorithm over other algorithms in the computation efficiency is more obvious with the increasing image size.

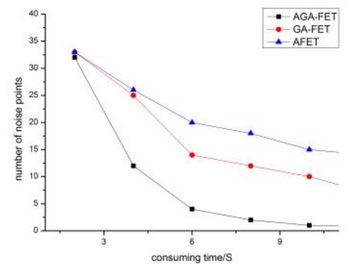

FIGURE 3 Comparisons of impulse noise for a same picture using AFET, GA-FET and AGA-FET

The visual comparisons of graphic performance indexed by colour saturation for a same picture using AFET, GA-FET and AGA-FET is shown in figure 4.

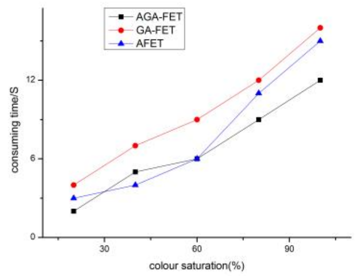

FIGURE 4 Comparisons of colour saturation for a same picture using AFET, GA-FET and AGA-FET

5 Conclusions

This paper prompts a adaptive genetic algorithm graphics design method based on fuzzy entropy thresholding which can improve the quality of digital graph. The AGA-FET method proposed in this paper overcomes such defects of the traditional FET method as low computation efficiency of the exhaust algorithm and poor adaptability to the various images resulting from presetting the bandwidth of membership function. In the meantime, the AGA-FET method performs better than the GA-FET method by overcoming the possible pre-maturity. Extensive simulations have demonstrated that the AGA-FET method can adaptively determine the bandwidth of membership function and optimal threshold and it has good robust performance and high computational efficiency. The experiment shows that the AGA-FET method proposed in this paper overcomes such defects of the traditional FET method as low computation efficiency of the exhaust algorithm and poor adaptability to the various images resulting from presetting the bandwidth of membership function.

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