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Educational reform informatisation based on fractional differential equation

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Abstract

In order to solve the problem that the image processing time is too long in the use of the original college education information power method, therefore, the design of the fractional differential equation of higher education information power method was created. According to the information source, a combination of various methods is set to complete the data collection. Compared with the content of fractional differential equation, the fractional differential equation is selected to complete the image information processing, develop the processing process and select the appropriate equipment to complete the image processing, set up the experimental equipment, and select the experimental samples to obtain the experimental results. Compared with the original method, the image processing time of this method is significantly shorter than that of the original method. Therefore, this method is more efficient for image processing and has a more obvious effect on the informatisation of university education.

Keywords: college education informatisation, power method, fractional order differential equation, data acquisition, image processing, multimedia teaching

AMS 2010 codes: 97B10

1 Introduction

The informatisation construction of higher education is one of the key objectives of modern higher education [1]. With the continuous development of computer technology, information technology will bring great changes to higher education. In order to become the driving force and source of China's economic and social development and to play its 'locomotive' role, colleges and universities must construct an information system suitable for modern education and ensure the effective play of education, scientific research and social service functions. In view of the present situation of China's modern education, the Report on the Outline of the Tenth Five-Year Plan for the Social Development of the National Economy has been issued recently, in which it is pointed out that the main task of higher education is to promote the informatisation process in the field of education.

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Therefore, how to complete the university education information construction is a key research topic. Image processing time is too long in the previous power methods [2]. With the development of network technology and computers, digital video and digital image have become one of the important information carriers. People have a higher requirement about the quality of the digital image, but in the process of digital image acquisition and transmission, it produces some unnecessary noise, which makes the image denoising to become more and more important. There are many image denoising methods, such as anisotropic image denoising method based on fractional differential equation, wavelet filtering method, variational method and so on. Among them the image denoising model based on fractional differential equation has become a research hotspot [3].

Based on the traditional fractional-order differential equation image denoising model and combining the texture structure features of the image, this paper introduces the differential curvature, and it is found in the study that the fractional-order differential operator plays an obvious role in improving the high-frequency component of the image. Moreover, the new model can enhance the intermediate frequency component of the image and preserve the non-linear low frequency component of the image. The new model can self-adaptively denoise the image. The simulation results verify the effectiveness of the model and the algorithm.

The increasingly important part of educational equity is partly based on the correlation of the individual education level with the future quality of life. Differential equations (DE) of educational equity are related to achievement, fairness and opportunity. Therefore, the pedagogy of pedagogy gives education equity provides a strong foundation for social justice. However, language barriers challenge DE's equity education. Karimi-Fardinpour et al. work in a way to create a stock educational environment that supports students' social justice mathematics and satisfaction with students. According to the principles and standards of the 2000 Mathematics Teachers Committee (NCTM) in school mathematics, mathematics coaches should strive to meet the requirements of the principles and standards. However, complying with criteria like equity principles can be a daunting task. The diversity of differential evolution (DE) students' language abilities may enrich the educational environment, but it also raises challenges [4].

The nonlinear grey Bernoulli model NGBM (1,1) has been successfully applied to various fields. The main advantage is that the power index can better reflect the nonlinear properties of the raw data. However, the parameters of the model (i.e. accumulation, background value coefficients and power exponents) must be optimised to accommodate the development of the system. Xie et al. proposed a fractional nonlinear grey Bernoulli model (MFNGBM [1,1]) to reduce the perturbation limit of the classical NGBM and further improve the exact accuracy of the model, which uses mutual fractional operators and new optimisation schemes to predict educational investments using DE algorithms. In this scheme, the Bernoulli differential equation, the power index of the background coefficient and the original sequence are taken as determination variables, and the optimal parameters obtained through iterative adjustment of the fit function. Experimental evaluations performed on two types of open-source data show that the proposed approach can be very competitive against popular baselines [5].

Therefore, in this design, in view of this problem to design a new power method, that is, fractional differential equation of college education information power method. On the design of the power method, in the process of information processing, the fractional order differential equation is used to improve the speed of information processing. In terms of image processing efficiency, the fractional order differential equation is used to complete the design of the assisted method. The test shows that this method can effectively solve the problem of too long image processing time of the original method.

2 Model in this paper

2.1 P-M model

In 1990, Perona and Malik proposed a nonlinear anisotropic diffusion equation, namely the P-M model, in order to maintain image edge information. The definitions are as follows:

$$\begin{cases} \frac{\partial u(x,y,t)}{\partial t} = \text{div}(g(|\nabla u|)|\nabla u|), \\ u(x,y,0) = u_0(x,y), \end{cases} \quad (x,y) \in \Omega \quad (1)$$

In Eq. (1), ∇ is the gradient operator; div is the divergence operator; $|\nabla u|$ is the image gradient modulus value; u_0 represents the initial noisy image; Ω is the area contained in the experimental image; and the diffusion coefficient $g(|\nabla u|)$ is a function of $|\nabla u|$, the expressions of anisotropic diffusion coefficient $g(|\nabla u|)$ 2 proposed by Perona and Malik are as follows:

$$g_1(|\nabla u|) = \exp\left(-(|\nabla u|/K)^2\right) \quad (2)$$

$$g_2(|\nabla u|) = \frac{1}{1 + (|\nabla u|/K)^2} \quad (3)$$

wherein K is the gradient threshold. The P-M model diffuses the noisy image by the size of the gradient. The $|\nabla u| > K$, $g(|\nabla u|) \rightarrow 0$ diffusion stops; the $|\nabla u| < K$, $g(|\nabla u|) \rightarrow 1$, corresponds to smooth filtering.

2.2 Principle of algorithm

In 2010, a new edge detection operator, namely the differential curvature operator, was proposed. The expression is as follows:

$$D = ||u_{\eta\eta}| - |u_{\xi\xi}|| \quad (4)$$

In Eq. (4), u_{ξ} and u_{η} , respectively, represent the second derivatives of the image in the horizontal and gradient directions. The unit vectors of horizontal and gradient directions are as follows:

$$\xi = \frac{[-u_y, u_x]}{\sqrt{u_x^2 + u_y^2}} \quad \text{and} \quad \eta = \frac{[u_x, u_y]}{\sqrt{u_x^2 + u_y^2}} \quad (5)$$

$$u_{\xi\xi} = \frac{u_{xx}u_y^2 - 2u_{xy}u_xu_y + u_{yy}u_x^2}{u_x^2 + u_y^2}, \quad (6)$$

$$u_{\eta\eta} = \frac{u_{xx}u_x^2 - 2u_{xy}u_xu_y + u_{yy}u_y^2}{u_x^2 + u_y^2}$$

Among them

$$\begin{aligned} u_x(i,j) &= \frac{u_{i+1,j} - u_{i-1,j}}{2}, \\ u_y(i,j) &= \frac{u_{i,j+1} - u_{i,j-1}}{2}, \\ u_{xx}(i,j) &= u_{i+1,j} - 2u_{i,j} + u_{i-1,j}, \\ u_{yy}(i,j) &= u_{i,j+1} - 2u_{i,j} + u_{i,j-1}, \\ u_{xy}(i,j) &= \frac{(u_{i-1,j-1} + u_{i+1,j+1}) - (u_{i-1,j+1} + u_{i+1,j-1})}{4} \end{aligned} \quad (7)$$

Type (7): $u_{i,j}$ represents the value of the function u at the node (I, j) , $u_{i+1,j}$, $u_{i-1,j}$, $u_{i,j+1}$, $u_{i,j-1}$, something like the definition of $u_{i,j}$, $u_{i,j}$ represents the value of the first partial derivative of u with respect to x at the node (I, j) , $u_y(i, j)$, $u_{xx}(i, j)$, $u_{yy}(i, j)$, $u_{xy}(i, j)$, something like the definition of $u_x(i, j)$.

According to Eq. (4), in the edge region of the image, if $U \xi$ is smaller, $u \eta \eta$ is larger, then the differential curvature D value will be larger. In the flat region of the image, if $U \xi$ and $u \eta \eta$ are both small, then D value is small; At the isolated noise points of the image, if $U \xi$ and $u \eta \eta$ are both large, almost equal, then D value is small. So depending on the difference curvature D value, better distinguish the flat areas, edges and noise points in the image [6, 7].

Based on the properties of differential curvature and fractional-order operator, the diffusion coefficients are proposed as follows:

$$g(\nabla u, d, v) = \frac{1}{1 + \left(\frac{G_\sigma |(\nabla u + d)|^v}{k} \right)^2} \quad (8)$$

The new model can be obtained as:

$$\begin{cases} \frac{\partial u(x, y, t)}{\partial t} = \text{div}(g(\nabla u, d, v) \nabla u), \\ u(x, y, 0) = u_0(x, y), \end{cases} \quad (x, y) \in \Omega \quad (9)$$

Type (9): d is the normalised differential curvature, $d = \frac{D - \min D}{\max D - \min D}$, $G_\sigma(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2 + y^2}{2\sigma^2}\right)$ is the Gaussian kernel function, k is the threshold value, taking the constant.

In this paper, the order of fractions is an adaptive process related to local variance:

$$v = 1 + \frac{\sigma_{x,y}^2 - \min(\sigma_{x,y}^2)}{10 \times \max(\sigma_{x,y}^2)} \quad (10)$$

Type (10): $\sigma_{x,y}^2 = \frac{1}{m_1 \times m_2} \sum_{x_i, y_j \in H} (u_{x_i, y_j}^2 - \mu_{x_i, y_j}^2)$, $\mu_{x_i, y_j} = \frac{1}{m_1 \times m_2} \sum_{x_i, y_j \in H} u_{x_i, y_j}$. Where, μ_{x_i, y_j} and $\sigma_{x,y}^2$ are the local mean and local variance of the noisy image u , respectively; H is a rectangular window of $m_1 \times m_2$, centred on (x, y) .

2.3 Numerical implementation

The time interval is set as Δt , the space step size is 1, (I, j) represents the discrete points in the image and the iterative formula after the dispersion of the model in this paper is as follows:

$$u_{i,j}^{n+1} = u_{i,j}^n + \frac{\Delta t}{4} \sum_{l=1}^4 \left(g(|\nabla u_{i,j}^n|^l) d_{i,j}^n, v \right) \quad (11)$$

$|\nabla u_{i,j}^n|$, ($l=1, 2, 3, 4$) represent the gradient of the four neighbourhood directions of upper, lower, left and right, respectively, namely:

$$\begin{cases} |\nabla u_{i,j}^1| = u_{i,j-1} - u_{i,j} \\ |\nabla u_{i,j}^2| = u_{i,j+1} - u_{i,j} \\ |\nabla u_{i,j}^3| = u_{i-1,j} - u_{i,j} \\ |\nabla u_{i,j}^4| = u_{i+1,j} - u_{i,j} \end{cases} \quad (12)$$

The mean fractional order differential equation combined with multivariate mixed criterion is used to complete the information processing process [8, 9]. The image information to be processed is set as a matrix, which is

named W , and the dimension of the information vector is set as C_i ($i = 1, 2, \dots, n$), and n is the number of vectors. For image expansion and initialisation processing, it can be known that its mean region is J_i , then:

$$\sum_{i=1}^w J_i = 1 \quad (13)$$

Set the fuzzy centre as Z and the information number as L , then:

$$Z_i = \frac{\left(\left(\sum_{i=1}^w J_i \right)^L C_i \right)}{\left(\sum_{i=1}^w J_i \right)^L} \quad (14)$$

The image blur processing centre is obtained through Eq. (14), the image information is processed with this as the reference point, and the processing results are obtained [10]. Setting the processing information as Y and H as the frame length of image information, then:

$$Y = \frac{\left\{ \left(\frac{1}{H^2(C_i, Z_i)} \right)^{\frac{1}{L-1}} \right\}}{\left\{ \sum_{i=1}^w \left(\frac{1}{H^2(C_i, Z_i)} \right)^{\frac{1}{L-1}} \right\}} \quad (15)$$

2.4 Algorithm steps

(1) First, the second-order derivative $U \xi$ and $U \eta \eta$ of the horizontal and gradient directions of the image are calculated using Eq. (6); (2) by substituting the values of $U \xi$ and $U \eta \eta$ into Eq. (4), the differential curvature D of the image can be obtained, and then D can be obtained through normalisation processing; (3) the values of four directional gradients can be obtained from Eq. (12), and the adaptive fractional order can be obtained from Eq. (10); (4) substitute the values obtained in Steps (2) and (3) into Eq. (8) to obtain the value of diffusion coefficient; (5) finally, the image containing noise is processed according to Eq. (11). Repeat the above steps until better denoising image effect is achieved.

3 College education informatisation assistance method design

According to the previous research, the traditional power assist method cannot complete the high-speed operation of information processing, it is necessary to set up a new method to solve this problem. Therefore, the

Fig. 1 Design process of college education informatisation assistance method.

algorithm selection is very important in this design [11]. Combined with the characteristics of higher education informatisation, the mean fractional order differential equation is selected to complete the design. The specific design process is shown in Figure 1.

The above process is used to complete the design of the method. As an auxiliary method of information construction, the technology and equipment used in the method should ensure that it does not conflict with the information construction of higher education. Emphasis should be paid to the integration of information technology and intelligent algorithms to promote the development of information construction in higher education.

3.1 Acquisition of educational information construction

Image information contains a lot of information which needs to be processed in the construction of university education informatisation. The original power method of image information processing ability is poor, so the information collection work has become the basis to improve the processing efficiency, and set a comprehensive information collection method to help improve the information processing ability. In order to collect and preserve all the information in the informationisation construction without causing the loss of information, the new data extraction technology is introduced in the part of information collection and acquisition.

In the process of information construction, information sources are abundant and forms are varied. When the above information is collected, the traditional single collection method cannot complete the collection of multiple forms of text and image. The single data and information acquisition network is transformed into a sensor acquisition network, and the image and voice information are collected by wireless induction sensor. Combined with the original information acquisition channel, the comprehensive construction information acquisition is realised.

3.2 Complete image information noise reduction

For the collected information, fractional differential equation is used to complete the noise reduction. Common fractional DES contains many contents, so choosing the method suitable for image information is the key problem in this design. There are many kinds of common fractional-order DES. In order to ensure the feasibility of the calculation process, the content of fractional-order DES is compared to complete the selection of algorithms. The contents of commonly used fractional DES are shown in Table 2.

3.3 Realise the information assistance work

Using the above design to complete the image processing speed is too slow power work, on the power method design in addition to the algorithm setting, increasing the processing process part. The specific process is shown in Figure 2. The process in Figure 2 was used to complete the processing work, because the amount of processed data was too large. In the process of processing to ensure the normal operation of the algorithm, the 8-core embedded CPU is used to control the computing equipment. In the process of calculation, the consistency of the unit quantity of information should be guaranteed, the unified information format should be set, and the exclusive database should be built to complete the information storage after processing to avoid the loss of data and information. In order to solve the problem that the processing time of image information is too long in the construction of university education information, a new method is designed which takes into account the multi-component mixed criterion fractional differential equation. In order to ensure the feasibility of the method design, experimental links were set to study its application effect.

Fig. 2 Image information processing flow.

4 Simulation experiment and result analysis

4.1 Objective evaluation indexes of image denoising

In this paper, the effectiveness of image denoising is evaluated objectively by the peak signal-to-noise ratio (PSNR) and structural similarity (SSIM). The larger the PSNR value, the higher the denoising ability, and the higher the SSIM, the more similar the structure. The expressions are as follows:

$$PSNR = 10 \times \lg \frac{255}{\frac{1}{M \times N} \sum_{i=1}^M \sum_{j=1}^N (u_0(i, j) - u(i, j))^2} \quad (16)$$

$$SSIM(u, u_0) = L(u, u_0) * C(u, u_0) * S(u, u_0) \quad (17)$$

where M and N represent the length and width of the image, and $M \times N$ represents the number of pixels in the image, $u_0(i, j)$ represents the original image and $u(i, j)$ the denoising image, Type (17):

$$\begin{aligned} L(u, u_0) &= \frac{2\mu_u \mu_0 + C_1}{\mu_u^2 + \mu_0^2 + C_1} \\ C(u, u_0) &= \frac{2\sigma_u \sigma_0 + C_2}{\sigma_u^2 + \sigma_0^2 + C_2} \\ S(u, u_0) &= \frac{\sigma_{u_0 u} + C_3}{\sigma_u + \sigma_{u_0} + C_3} \end{aligned}$$

where μ_u and μ_0 represent the mean values of images u and u_0 , σ_u and σ_{u_0} are the standard deviations of images u and u_0 , σ_u^2 and $\sigma_{u_0}^2$ represent the variance of images u and u_0 , respectively, $\sigma_{u_0 u}$ is the covariance of the graph with u , and C_1 , C_2 , C_3 are constants respectively, $C_3 = \frac{C_2}{2}$.

The collected information will be recycled by the above setting algorithm until the final value does not drop any more, and then the processing process is over. In the processing process, the colour data is preset to complete the convergence from the local to the centre, so as to improve the efficiency of large-scale data processing. In contrast, the fractional differential equation is more appropriate.

4.2 Experimental demonstration and analysis

In order to verify the effectiveness of the method designed in this paper, which takes into account the multivariate mixed criterion fractional differential equation, the test environment is constructed to complete the test of its effect. In the process of testing, the study was completed in the form of comparison with the traditional power assist method.

(1) Experimental equipment

To ensure the effectiveness of the testing process, the testing environment was constructed. In the process of this experiment, in order to ensure the use effect of the algorithm, set the parameters of experimental equipment

as shown in Table 1. According to the above equipment parameters, complete the selection and design of the test equipment. This equipment is used to complete the method test and complete the processing of the set experimental samples.

Table 1 Experimental equipment parameters

Testing environment	Content	Parameter
Software environment	Database	HBase
	Operating platform	Win8.1
	Operating system	IOS
	Data processing	DOMAS
Hardware environment	The Data Processor	Intel i9-7900x
	Host machine	GTX1050T
	Display	AOC C27B1H
	Video Card	QTX1060

(2) The experimental samples

In the process of information construction, it is necessary to deal with the mass data inside the university. Therefore, in this test, the sample size of five kinds of information data is set. The original method and the design method in this paper are used to complete the processing of data samples, and the effect of the design is judged by the processing time. The specific sample size and form settings are shown in Table 2.

Table 2 Test data

Sample number	Number	In the form of
A1	10000	jpg
A2	15000	jpg
A3	30000	jpg
A4	50000	jpg
A5	100000	jpg

Using the above data samples, the original method and the design method in this paper are used to complete the auxiliary processing work in the case of the data samples as above. The processing time is represented in a Table.

(3) The experimental results

Use the above settings to complete the test, the test results were presented in the form of a table. The test results of the design method in this paper were set as the experimental group, while the original method was set as the control group. The specific experimental results are shown in Figure 3.

According to the above experimental results, there is a huge difference between the experimental results obtained by using the original method and the method in this paper. With the increase of experimental samples, the processing time of the original method and the proposed method increases. However, through comparison, the processing time of the original method is significantly longer than that of the design method in this paper. When the sample size is 100,000, the processing time of the original method is 45 s, which is much higher than that of the design method in this paper. It can be seen that the auxiliary effect of the design method in this paper is better than that of the original method in the informationisation construction of university education, and the design method in this paper should be popularised and applied.

Fig. 3 Comparison of experimental results.

5 Conclusion

Combining the advantages of differential curvature and fractional differential operator, an adaptive image denoising model is proposed in this paper. Combining the properties of image gradient, differential curvature and fractional order differential operator, the proposed model can better protect the edge details and other information of the image, and has a good balance between noise removal and image feature protection, which makes up for the deficiency of the P-M model in image processing. Finally, the correctness and effectiveness of the model are verified by experiments, that is, with the increase of noise variance, the model in this paper still has a good effect of noise removal and has certain practicability.

The design of the power method requires the application of fractional differential equation calculation and processing ability, and the integration of the diversified data in the information technology of higher education. For large-scale image data processing, it has a better processing effect, and the processing speed is obviously higher than the existing methods. Setting the test environment for the design results and the original power method for comparison, the design results are better than the original method of the test results. Therefore, the design results should be applied to the information construction of university education, improve the speed of information construction, and ensure the development of modern education in our country. Modernised education is the cornerstone of China's education development. Only by improving its level can we guarantee the continuous improvement of China's education level.

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