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Design and Analysis of Dynamic Fuzzy Image Restoration

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Abstract: In real life, we often need to extract useful information from dynamic blurred images, so it is necessary to establish a reasonable model and recover as clear a picture as possible from the dynamic blurred image. Firstly, the model analysis of dynamic fuzzy images is carried out. Considering various interference factors, a point spread function (PSF) is constructed on the basis of the degenerate model, so that the parameters necessary for restoring the model are clearly established. Secondly, the parameter processing is performed, the Sobel edge detection operator is used to identify the blur angle of the image, the auto-correlation curve is used to obtain the blur length of the image, and the corresponding noise reduction correction processing is performed on the motion blurred image. Finally, the dynamic fuzzy image restoration is established. The model is analyzed and the improved BP neural network model is established according to the fuzzy parameters obtained by image processing. The dynamic fuzzy image material is restored and analyzed, and the reliability of the dynamic fuzzy image restoration processing is verified.
Keywords: Dynamic Blurred Image; PSF; Image Restoration; BP Neural Network.

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1. CLASSIFICATION OF DYNAMIC BLURRED IMAGES

Based on the object that produces the motion, we classify the motion blurred image:

(1) Global motion blur caused by motion of the imaging device.

(2) Local motion blur caused by the motion of the subject.

(3) Mixed motion blur caused by both the imaging device and the subject moving.

2. DYNAMIC FUZZY IMAGE MODEL ANALYSIS

Since there are many reasons for generating a dynamic blurred image, the established model is also different. This paper is mainly to establish a recovery model of blurred images caused by the relative motion of the camera.

2.1 Noise analysis of original image

Noise expectation: $E\{n(x,y)\}$;Noise variance: $E\{(n(x,y)-E\{n(x,y)\})^2\}$;Noise power: $E\{n^2(x,y)\}$.

It can be defined as follows: the grayscale image can be expressed as a two-dimensional luminance distribution f (x, y), where (x, y) is the pixel coordinate, the corresponding function value f (x, y) is the pixel value gray, and the noise is It can be regarded as interference to the gray value of the pixel.

The commonly used function n (x, y) indicates that the image interfered by noise is represented by g (x, y).

The input image f (x, y) is outputted by a degraded system and is a degraded image. For the convenience of discussion, the noise-induced degradation, that is, the influence of noise on the image is generally considered as additive noise.

2.2 Dynamic fuzzy image degradation model analysis

The original image f (x, y) is superposed by a degradation operator or degenerate system h (x, y) and then superimposed with the noise n (x, y) to form a degraded image g (x, y). Fig.1 shows the relationship between the input and output of the degradation process, where h(x,y) summarizes the physical process of the degenerate system, which is the degenerate mathematical model to be sought.

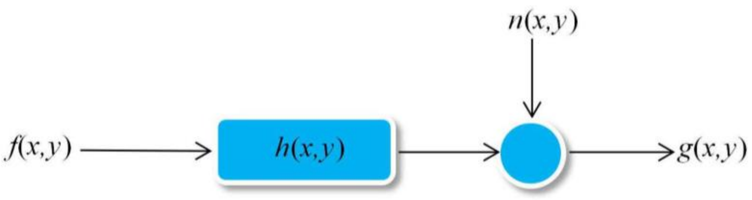


Fig.1 Degradation model of uniform linear dynamic blurred image

The degenerate point spread function is denoted as h (x, y), and the image blur model caused by camera motion can be described by Figure 1 [1]. Assuming that the degenerate system is a linear space-invariant system, further formulas indicate that the degradation process is:

$$g(x,y) = f(x,y) * h(x,y) + n(x,y) \tag{1}$$

Where: h (x, y) is called a fuzzy operator or a point spread function: * denotes convolution; f (x, y) denotes the original image; g (x, y) denotes the observed degraded image. In the frequency domain you can write:

$$G(u,v) = F(u,v)H(u,v) + N(u,v) \tag{2}$$

Where: G(u, v), F(u, v), N(u, v) are the degraded image g(x, y), the original image f(x, y), and the noise signal n(x, y) Fourier transform; H(u, v) is the Fourier transform of the point impulse response function h(x, y) of the system, called the transfer function of the system in the frequency domain.

2.3 Dynamic blurred image point spread function

Suppose that an image f (x, y) is acquired for a scene moving at a uniform plane, and $x_0(t)$ and $y_0(t)$ are the motion components of the scene in the x and y directions, respectively, and T is the length of the acquisition time. Ignoring other factors, the continuous function model of the blurred image is as follows:

$$g(x,y) = \int_0^T f[x - x_0(t), y - y_0(t)]dt \tag{3}$$

Perform Fourier transform on both sides of equation (3) to get the point spread function:

$$H(u,v)=\int_0^T \exp[-j2\pi(ux_0(t)+vy_0(t))]dt \tag{4}$$

It can be known from the above formula that as long as the motion component of the moving object in the horizontal direction x and the vertical direction y, $x_0(t)$, $y_0(t)$, is known, the point spread function of the motion blurred image can be determined. Here we introduce two important parameters of two fuzzy motions: the fuzzy scale L and the motion blur angle θ .

Because of $L=\sqrt{x_0(t)^2+y_0(t)^2}$, $\tan\theta=\frac{x}{y}=\frac{x_0}{y_0}$, $\theta=\arctan\frac{x_0(t)}{y_0(t)}$,the image can be restored as long as the parameters L and θ of the blur motion are known.

3. PARAMETER PROCESSING OF DYNAMIC BLURRED IMAGES

3.1 Identify dynamic blur angles

The edge detection operator is a simple and feasible method to identify the dynamic blur angle. The edge point is determined by investigating the gray level change of each pixel in the neighborhood and calculating the first or second order reciprocal value. In this paper, the Sobel edge detection operator is used to identify the blur angle. The operator consists of two sets of matrices, horizontal and vertical, which are convolved with the image to obtain the horizontal and vertical luminance difference approximations. If A represents the original image, G_x and G_y represent images detected by the lateral and longitudinal edges, respectively, and the formula is as shown in equation (5). The horizontal and vertical gradient approximations for each pixel of the image can be combined with equation (6) to calculate the magnitude of the gradient. The gradient direction can be calculated using equation (7).

$$Gx=\begin{bmatrix}-1 & 0 & +1\\ -2 & 0 & +2\\ -1 & 0 & +1\end{bmatrix}\times A \quad Gy=\begin{bmatrix}-1 & -2 & -1\\ 0 & 0 & 0\\ +1 & +2 & +1\end{bmatrix}\times A \tag{5}$$

$$G=\sqrt{G_x^2+G_y^2} \tag{6}$$

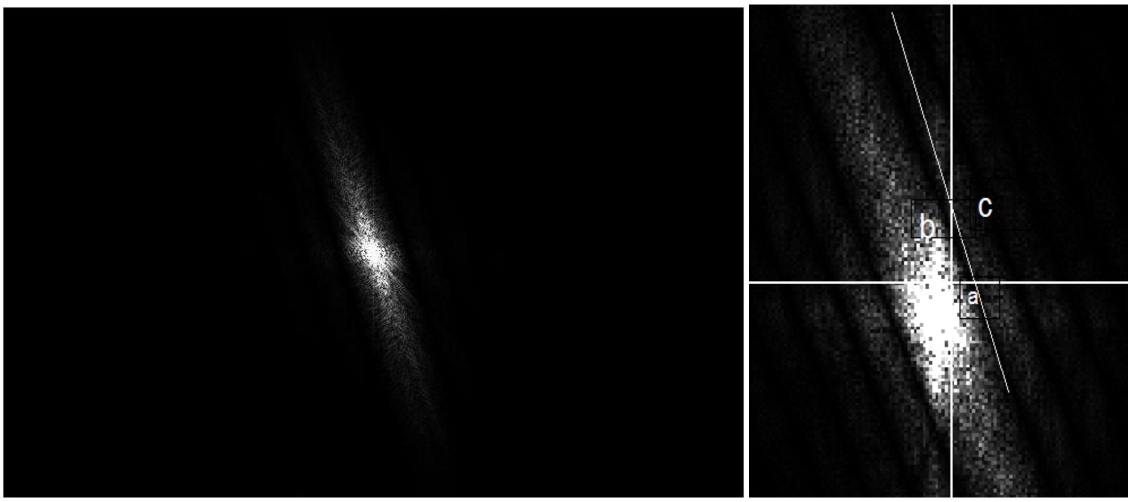
$$\theta=\arctan\left(\frac{G_y}{G_x}\right) \tag{7}$$

Using the Metlab software to identify the blur angle using the Sobel algorithm for the dynamic blurred image, the fuzzy angle diagram is shown in Fig.2.

In this paper, the Fourier transform spectrum image is obtained by Fourier transform (Fig. 2(a)). Through the Fourier transform spectrum, the triangle shown in Figure 2. (b) is selected by Matlab's own ginput tool to calculate the relationship between a and c. The angle of the angle, thereby obtaining the blur angle of the dynamic blurred image.

(a) Dynamic blur original image (b) Processed image (c) Edge detection

Fig.2 Fuzzy angle discrimination



(a) Fourier transform spectrum (b) Angle calculation

Fig.3 Fuzzy angle calculation

According to the processing of Matlab, the corresponding data can be obtained. According to the obtained data, the atan(20/9)*180/pi can be calculated by Matlab, and the obtained angle is 65.9457° , and the moving direction is 90-65.9457° ≈24° , this is the dynamic blur angle of the motion blurred image.

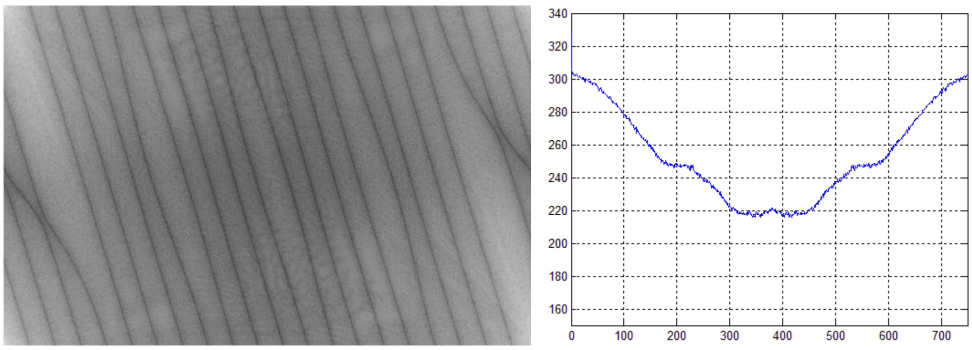
3.2 Discriminating dynamic blur length

Assuming that h(x) is a point spread function, it is proportional to a single bright point staying at (x, x + dx) for a time dt, and the point spread function PSF for the actual exposure is h. For the interception of (x), the length of the point spread function is d. If f(x) represents the original image and y(x) represents a blurred image, then there is a formula:

$$y(x) = f(x) * psf(x) = \int_{-\infty}^{\infty} f(\alpha) h(x-\alpha) rect(\frac{x-\alpha}{d}) d\alpha \qquad (8)$$

After performing the autocorrelation operation in the horizontal direction on the differentiated image, the S(x) graph can be drawn according to the operation result, and the horizontal distance between the first minimum point on the left and right sides of the peak in the middle of the graph is obtained, which is the blur. Two times the length of the exercise. The image is subjected to horizontal differentiation by the above formula to obtain a differential image. The horizontal autocorrelation operation is performed on the differential image by using equation (8) to obtain a horizontal autocorrelation image. The autocorrelation image is treated as a matrix, and the column sum is obtained, and a one-dimensional array of autocorrelation image columns is obtained. Draw a one-dimensional array graph and observe the horizontal distance between the first and smallest values on the left and right sides near the middle of the curve. The length of the blur motion is half of the distance obtained above.

According to the above steps, using Matlab for programming modeling, the dynamic blur length of the dynamic blurred image can be obtained. The fuzzy frequency is shown in Fig. 4.



(a) Fuzzy frequency (b) Frequency curve

Fig. 4 Fuzzy frequency map

Its autocorrelation curve is shown in Fig.5. Using Matlab 's Data Cursor, the distance between the two negative peaks can be measured as 21 pixels, which is the length of the motion blur.

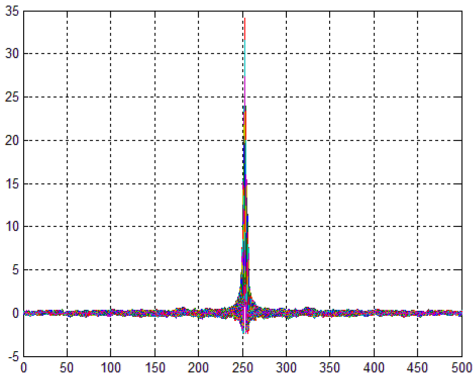


Fig.5 Autocorrelation curve

3.3 Noise reduction processing of dynamic blurred images

Noise is mainly divided into external noise and internal noise. A denoising model is built for internal noise. Considering the difficulty of Gaussian noise filtering, we use the neighborhood averaging method to eliminate Gaussian noise. The idea of the neighborhood averaging method is to use the average or weighted average of the pixels in the pixel and its specified field as the new value of the pixel, in order to remove the abrupt pixel points, thereby filtering out certain noise. the neighborhood average expression is:

$$g(x,y)=\frac{1}{M}\sum_{(m,n)\in s} f(x-m,y-n) \tag{9}$$

Where: S is a neighborhood of points (x, y) (excluding the point) M is the total number of pixels contained in the neighborhood. The neighborhood averaging method can be expressed as:

$$g(x,y)=f(x,y)*h(x,y)=\sum_{(m,n)\in s}\sum h(m,n)f(x-m,y-n) \tag{10}$$

Thus, the corresponding h (x, y) can be calculated from the corresponding radius. The image is denoised by Matlab, and the processed image is shown in Fig.6.

Fig.6 Noise reduction processing diagram

4. ESTABLISHMENT AND ANALYSIS OF RECOVERY MODELS

In order to obtain a better dynamic fuzzy image restoration model, two improved models of BP neural network model are established based on the parameter analysis results, and the dynamic fuzzy image material is restored.

4.1 Improvement of bp neural network model

The traditional inverse filtering method can only achieve better recovery effect under the condition of extremely high signal-to-noise ratio (SNR). In view of the shortcomings of the traditional Wiener filtering recovery model, this paper establishes a different method from the traditional image restoration method. Model - an improved BP neural network model.

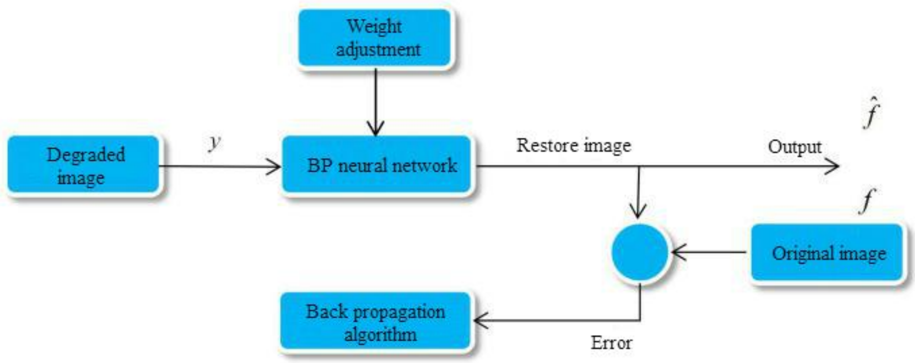


Fig.7 BP network model for image restoration

The BP network is a multi-layer feedforward network using backpropagation algorithm, which can approximate any nonlinear mapping relationship and has good pan-China capability. In the field of image processing, it is widely used as a non-adaptive neural network technology [2]. For the image blur problem caused by the relative movement of the camera solved in this paper, the BP neural network model is designed as shown in Fig.7.

1) Design of neural network structure

Experiments show that a three-layer BP network can perform arbitrary n-dimensional to m-dimensional mapping. This paper uses a single hidden layer BP network. In this paper, the training image is sampled by a 4×4 sliding window, so the number of input layer nodes is 32. Considering that this paper uses BP network for regression, the number of output layer nodes is 16. the choice of the number of hidden layer nodes is a very complicated problem. Experiments show that the number of hidden layer nodes is 30, which can get faster convergence speed and smaller square error. The multi-layer feedforward grid using BP algorithm is the most widely used neural grid. It is generally used to refer to the single hidden layer feedforward network as a three-layer feedforward network. The so-called three layers include the input layer and the hidden layer. And the output layer [3], according to this question, we choose the three-layer feedforward network as shown in Fig.8, and on this basis, the BP neural network model is improved.

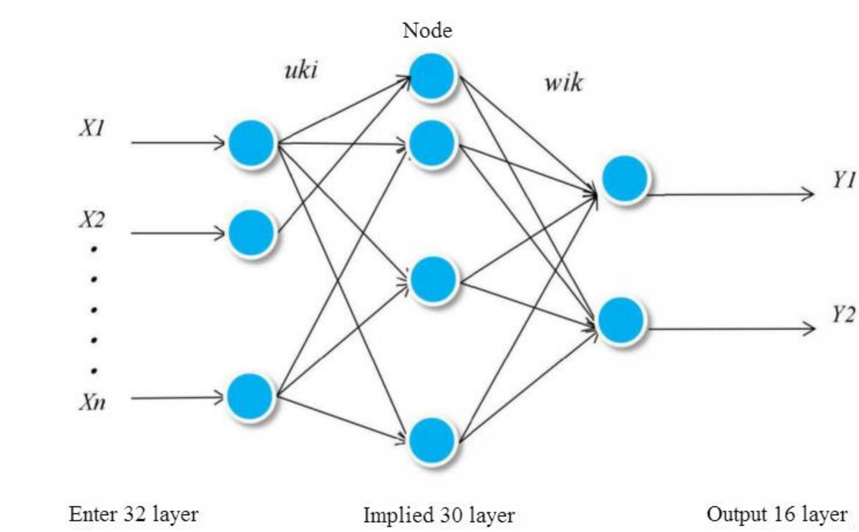


Fig.8 Three-layer feedforward network

2) Selection of input and output samples

In this paper, 4×4 sliding window structure is used to extract features, so the number of input layer nodes is 32. The BP neural network is improved, and it is used for regression. The number of output layer nodes is 16; the number of hidden layer nodes is A very complicated problem, after many experiments show that the number of hidden layer nodes is 30, which can get faster convergence speed and smaller square error. The Matlab programming model is thus used to obtain the input of the BP network.n input and output pairs (P_k , T_k) as training samples, P_k is the Kth target input vector, where M is the dimension of the input vector, and T_k is the Kth target output vector, where N is the dimension of the output vector, The actual output of the network is represented by O_k . When the window traverses the entire blurred image, the input matrix P of the BP network is obtained.

The choice of network transmission function plays a very important role in the convergence of the network. According to the requirements of the BP network algorithm, the transmission function must be everywhere. This paper uses the Sigmoid function as the transfer function [4]. Finally, the BP neural network model is used to restore the original image as shown in Fig.9.

(a) original dynamic blurred image (b) BP neural network restored image

Fig. 9 BP network model to recover dynamic blurred images

4.2 Model analysis and verification

From the perspective of the clarity of the restored picture, the improved BP neural network model can dynamically blur the image to a clearer effect. However, in the process of image algorithm processing, many cases need to be evaluated by objective evaluation indicators. In this paper, three better objective evaluation indicators—peak noise ratio PSNR, fuzzy coefficient K and quality index Q are used to evaluate the model [5].In general, the larger Q, the larger the PSNR, and the smaller the Kw, the better the image restoration effect, and vice versa. The evaluation results are shown in Table 1:

Table 1. BP neural network model evaluation results

Index	BP neural network model
Signal to noise ratio *PSNR*	0.9746
Fuzzy coefficient *Kw*	0.8451
Quality Index *Q*	23.5708

It can be seen from the data in the Table 1 that the improved BP neural network model recovers all the indicators of the image. In order to further verify the reliability of the recovery model, the image of the person restored by the BP neural network model is compared with the original dynamic blurred image again to verify whether the image quality index is improved, as shown in Fig.10.

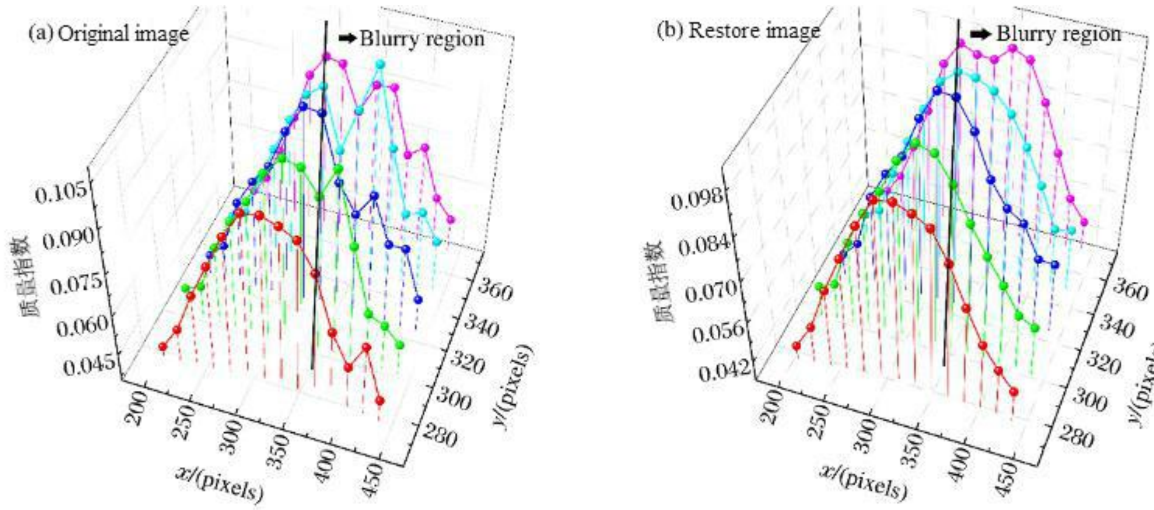


Fig.10 Comparison of original image and restored image quality index

It can be seen from Fig.10 that the quality index of each point on the image after restoration is improved. Therefore, the improved BP neural network model established this time is reliable for the recovery of dynamic blurred images.

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In this paper, the dynamic fuzzy image generated by the relative motion of the camera is analyzed reasonably. The degradation model of dynamic blurred image is established by considering the interference factors such as noise, and the point spread function (PSF) is constructed based on the degenerate model. The related parameters, the dynamic fuzzy image restoration model is established and analyzed, which fully reflects the superiority of the improved BP neural network model established this time.

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