



Research on Debounce Method of Electronic Imaging Equipment Based on Feature Point Matching

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Abstract. Aiming at the problem of image generation blur in existing electronic imaging equipment de-shake methods, this paper proposes a method of electronic imaging equipment de-shake based on feature point matching. First, perform feature point matching on the motion path of the electronic imaging device, obtain the motion characteristics of the device using constraint conditions, and implement the motion path feature matching processing of the electronic imaging device in combination with the matching feature window. Secondly, use the two-dimensional spatial relationship of the image to perform rotation, translation, and zoom processing on the resulting image. Based on the electronic imaging equipment operating model, the six-parameter radiation method is used for motion estimation, and the motion curve characteristics are determined and modified according to the base function synthesis curve. The optimized processing of the estimated value then obtains the de-shake result of the electronic imaging device. The experimental results show that the PSNR value is about 72.64 dB and the MSE value is about 12.54 when the method in this paper is used for de-jitter processing, both of which are better than the traditional method. It can be seen that this method has a better de-jitter effect.

Keywords: Feature point matching · Electronic imaging equipment · Debounce · Image feature points

1 Introduction

With the increasing demand for images in various fields, many scholars and businesses have conducted a lot of effective exploration and research on electronic imaging equipment. With the increasing application of electronic imaging equipment, the equipment becomes more and more diversified, which can adapt to any scene, especially in a dynamic environment, it is easier to cause the electronic imaging equipment to shake and cause the image to blur. For this, de-shake It has become an urgent problem in this field [1].

Literature [2] proposes a de-jitter method based on a self-reference source, which does not require two similar sources to be measured under the premise of satisfying high measurement accuracy, which greatly reduces the complexity of the measurement system. Then, the structure of the measurement system is optimized, the mechanism of the artifact peak in the optical fiber delay line system is explained, and the second-order

difference frequency comb model is proposed to realize the de-jitter processing. Experimental results show that this method can effectively improve the accuracy of de-shake, but ignores the time-consuming situation; Literature [3] proposes to use the de-shake blur algorithm to restore the original image information of the blurred image, and then perform point-based restoration based on the motion recovery structure. The dense three-dimensional reconstruction of the cloud, and finally the Poisson surface reconstruction of the densely reconstructed point cloud to obtain the surface density and realize the de-jitter processing. The experimental results show that the de-jitter effect of this method is obvious, but it takes a long time. In this regard, this paper proposes a research on the de-shake method of electronic imaging equipment based on feature point matching. This method can not only solve the problem of blurred image, but also shorten the time of de dithering and improve the efficiency of de dithering method. The practical effect is good.

2 Feature Point Matching

In the process of electronic imaging equipment de-shake, this paper uses feature point matching algorithm for de-shake processing, but in fact, in the process of feature matching, the movement path of electronic imaging equipment directly affects the matching of feature points. The motion vector of the electronic imaging device is calculated [4]. Because the mapping transformation is transitive, the motion path of the electronic imaging device in the t -th frame can be represented by $C(t)$:

$$C(t) = F(t)F(t-1)\dots F(0) \quad (1)$$

In order to match the estimated operating path $C(t)$ of the electronic imaging device with the collected feature points, it is necessary to reduce the jitter caused by the movement of the electronic imaging device as much as possible, and this needs to be restricted:

$$O\{P(t)\} = \sum_t \|P(t) - C(t)\|^2 + \sum_t \left(\lambda_t \sum_{r \in \Omega_t} \omega_{t,r} \|P(t) - P(r)\|^2 \right) \quad (2)$$

where: Ω_t is the time-domain smoothing radius, $\omega_{t,r}$ is the Gaussian weight, and λ_t is the balance factor. Using the motion path algorithm of a single device, the motion characteristics of the device in each grid are estimated:

$$C_i(t) = f_i(t) + f_i(t-1) + \dots + f_i(0) \quad (3)$$

where: $f_i(t)$ represents the motion vector of the i -th grid.

The search starts from the center of the search area, that is, the origin. The search path uses a diamond search path to calculate the SAD value of each point [5]. The calculation formula is as follows:

$$SAD(i,j) = \sum_{m=1}^M \sum_{n=1}^N |I_1(m,n) - I_2(m+i+p,n+j+p)| \quad i,j = -p, \dots, p \quad (4)$$

Find the minimum SAD value, then its corresponding position is the matching feature window, and its center point is the matching feature point. The PROSAC algorithm is used to match the characteristics of the motion path, and the formula is as follows:

$$\begin{aligned} D(x,y,\sigma) &= (G(x,y,k\sigma) - G(x,y,\sigma)) * I(x,y) \\ &= L(x,y,k\sigma) - L(x,y,\sigma) \end{aligned} \quad (5)$$

3 Research on Debounce Method of Electronic Imaging Equipment

It is assumed that the motion form of any electronic imaging device can be represented by rotation, translation, and zoom. Among them, the zoom movement of the electronic imaging device includes the changes in the depth of field caused by the forward and backward movement of the carrier and the imaging changes caused by the changes in the parameters of the electronic imaging device [6]. Therefore, the movement of the electronic imaging device can be described by the following formula, let $(X, Y, Z)^T$ be a point on the scene in the coordinate system of the electronic imaging device, $(X, Y, Z)^T$ and $(X', Y', Z')^T$ are the three-dimensional coordinates of the same point at different times, and the corresponding point coordinates on the imaging plane are (x, y) and (x', y') . If the movement of the electronic imaging device is displacement, rotation and linear change, the relationship between $(X, Y, Z)^T$ and $(X', Y', Z')^T$ is:

$$\begin{bmatrix} X' \\ Y' \\ Z' \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} + \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix} \quad (6)$$

The translational movement of the electronic imaging device means that the device only has displacement in the x and y directions in two-dimensional space. If the device only has a translational movement, a translation model can be used:

$$p' = W(p, T) = p + T = \begin{pmatrix} x \\ y \end{pmatrix} + \begin{pmatrix} t_x \\ t_y \end{pmatrix} \quad (7)$$

In the formula: $p = (x, y)^T$ and $p' = (x', y')^T$ respectively represent the coordinates of the equipment operating point at the reference point and the current K -th point, and t_x and t_y are the offsets of p' relative to p on the x -axis and y -axis, respectively.

In addition to the translational movement, the electronic imaging device itself may also undergo rotational movement. In this regard, the zooming movement is described by the zoom factor s . Therefore, when the electronic imaging device may have translation, rotation, or zooming motion, the Similarity motion model can be used:

$$p' = s \begin{pmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{pmatrix} p + \begin{pmatrix} t_x \\ t_y \end{pmatrix} \quad (8)$$

In the formula: θ is the rotation angle and s is the zoom factor.

Connect the k -th point coordinate with the curve of the electronic imaging coordinate point, and determine the row and column displacement vector value of the current electronic device relative to the reference device according to the trough values of the two curves [7], the calculation formula is:

$$C(w) = \sum_{j=1}^N [Col_k(j+w) - Col_r(j+M)]^2 \quad 1 < w \leq 2M+1 \quad (9)$$

where: $Col_k(j)$ and $Col_r(j)$ are the projection values of the k -th point coordinates and the j -th column of the reference coordinate respectively, N is the length of the column, and M is the search width of the displacement vector relative to the reference coordinate point on one side. Assuming that W_{\min} is the value of w when $C(w)$ is minimum, the displacement vector of the k -th point coordinate relative to the reference coordinate in the vertical direction is:

$$\delta_c = M + 1 - W_{\min} \quad (10)$$

Assume that f_1 and f_2 are two coordinate points that differ only by (d_x, d_y) in position, and $f_2(x, y) = f_1(x - d_x, y - d_y)$. The corresponding Fourier functions are $F_1(w_x, w_y)$ and $F_2(w_x, w_y)$. According to the properties of the Fourier function, there are:

$$F_2(w_x, w_y) = e^{-j2\pi(w_x, w_y)} F_1(w_x, w_y) \quad (11)$$

Based on the phase shift characteristics of the Fourier function, suppose the cross power spectrum of the two coordinate points f_1 and f_2 is:

$$\frac{F_1(w_x, w_y) F_2^*(w_x, w_y)}{|F_1(w_x, w_y) F_2^*(w_x, w_y)|} = e^{-j2\pi(w_x, w_y)} \quad (12)$$

where: F_2^* is the conjugate function of F_2 .

According to the constitution of the category variance, when σ_B^2/σ_T^2 is the largest, the de-jitter performance is the best, and the threshold at this time is the best threshold, and usually the threshold with the largest σ_B^2 can be selected. Therefore, we select the

threshold T_r , that maximizes the variance between classes as the threshold of de-jitter R , namely:

$$T_r = \max_{T \in R} \left\{ P_{out} \sigma_{in} (\mu_{in} - \mu_{out})^2 \right\} \tag{13}$$

if the residual value of a point is less than T , it is a point within the coordinate, otherwise it is a point outside the coordinate. After removing all coordinate outer points, you can construct new coordinate points with the remaining inner points, and use this new point set to re-estimate the global debounce parameters [8]. Since the new point set is more in line with the law of global motion than the previous filtering, the re-estimated parameters will be more accurate.

In the construction of the operating model of electronic imaging equipment, a six-parameter radiation model is used for motion estimation [9]. Assuming that the initial value of the initial a_3, a_6, a_1, a_5 of the translational movement of the electronic imaging device is 1, and the initial value of a_2, a_4 is 0, the initial value of the intermediate parameter $a_1^k \sim a_6^k$ can be calculated by the formula. Then use the iterative algorithm to obtain the final parameter values based on this starting point, so that the i -th point is compensated with the motion vector corresponding to this parameter to best match the background of the $i - 1$ th point, that is, the minimum function value of the corresponding position is:

$$e = \frac{1}{n} \sum_{m=1}^n e_m^2, e_m = F_i(x_m, y_m) - F_{i-1}(x'_m, y'_m) \tag{14}$$

Among them, $F_i(x_m, y_m)$ is the m -th feature of the coordinates of the i -th point, and $F_{i-1}(x'_m, y'_m)$ is the m -th feature of the coordinates of the $i - 1$ th point.

The given original N horizontal motion vectors u_i are independent one-dimensional curves, and the coordinates of each point on the curve are (x_i, u_i) , where $(i = 0, 1, 2, \dots, N)$ uses the function $p(x)$ to perform curve fitting, and the goal is to minimize the sum of squares of the error $r_i = p(x_i) - u_i$ which is:

$$\sum_{i=0}^N r_r^2 = \sum_{i=0}^N [p(x_i) - u_i]^2 \tag{15}$$

In a geometric sense, it is to find the curve $y = p(x)$ with the smallest sum of squares of the distance from a given point (x_i, u_i) . The function $p(x)$ is called the fitting function or the least square solution. The method of finding the unit of the fitting function $p(x)$ becomes the minimum of curve fitting. Two multiplication.

Analyze the jitter caused by the movement of the electronic imaging device from the kinematics of the electronic imaging device [10]. The cause of the jitter is the drastic change of speed, that is, the change of acceleration. The visual effect caused by pure uniform acceleration movement is smooth, and the curve is synthesized through the basis function. The method, using control points to determine and modify the characteristics of the curve, the expression is:

$$p(t) = \sum_{i=0}^n p_i N_{i,k}(t) \quad (16)$$

Among them, $p_i (i = 0, 1, \dots, n)$ is the vertex of the control polygon, and $N_{i,k}(t) (i = 1, 2, \dots, n)$ is the K-order basis function.

Assuming that the current electronic imaging equipment is at time k , the state prediction equation of the electronic imaging equipment established to predict the current state during the operation of the equipment is:

$$S(k|k-1) = \Phi \cdot S(k-1|k-1) \quad (17)$$

In the formula, $S(k|k-1)$ is the predicted result, and $S(k-1|k-1)$ is the optimal result at the last running time.

In order to update the electronic imaging equipment, the covariance matrix p of $S(k|k-1)$ needs to be predicted, and the established equation is as follows:

$$P(k|k-1) = \Phi \cdot P(k-1|k-1)\Phi^T + Q \quad (18)$$

where: $p(k|k-1)$ is the covariance matrix corresponding to $S(k|k-1)$, $p(k-1|k-1)$ is the covariance matrix corresponding to $S(k-1|k-1)$, and Φ^T represents the transposed matrix of Φ , that is, the prediction of the state of the electronic imaging device.

Now the predicted result of the filling is obtained, and then combined with the predicted value and the measured value, the optimal estimated value $S(k|k)$ of the current state of the electronic imaging device is obtained. The updated equation is:

$$S(k|k) = \Phi \cdot S(k|k-1) + K_g(k) \cdot (Z(k) - H \cdot \Phi \cdot S(k|k-1)) \quad (19)$$

where: K represents the Kalman gain.

The size of the jitter component is the difference between the corresponding components of the global motion and the intentional motion. For the current coordinate k to be processed, the original cumulative motion vector is $Z_{raw}(k)$, and the smoothed motion vector after filtering is $Z_{Kal}(k)$, then the jitter parameter for generation compensation is $Z(k) = Z_{Kal}(k) - Z_{raw}(k)$, The rotation angle $\theta(k)$, horizontal and vertical compensation parameters $dx(k)$ and $dy(k)$ are obtained. In addition, the scale factor $x(k)$ to be compensated is the product of the reciprocal scale factors between all points from the starting point. The calculation method is as follows:

$$s(k) = \prod_{i=1}^k \frac{1}{s(i)} \quad (20)$$

A typical electronic imaging device jitter and blur model in the spatial domain can be expressed as:

$$g(x, y) = f(x, y) \otimes k(x, y) + n(x, y) \tag{21}$$

Among them: \otimes is the convolution operator, $f(x, y)$ is the potential original coordinates, $k(x, y)$ is the fuzzy kernel of the point spread function, and $n(x, y)$ is the noise.

Perform direct inverse filtering of the electronic imaging device to restore it. In this step, the estimated value f of the Fourier transform of the original electronic imaging device $\hat{F}(u, v)$ is calculated by dividing the Fourier transform of the degraded device g by the Fourier transform of the degradation function h , As shown in the following formula:

$$\hat{F}(u, v) = G(u, v)/H(u, v) \tag{22}$$

However, if noise is added to the degradation function, the result of the direct inverse filtering will be very poor. Therefore, the degradation function of the equipment degradation restoration model is replaced with $K(u, v)$, and the estimated value optimization formula is:

$$\hat{F}(u, v) = F(u, v) + N(u, v)/H(u, v) \tag{23}$$

The above formula shows that even if the degradation function is known, the leaf cannot accurately remove the jitter that exists in the electronic imaging device [11]. In this regard, the electronic imaging equipment is subjected to non-linear iterative processing, so that the number of iterations of the de-shake operation of the equipment reaches the maximum, as shown in the following formula:

$$\hat{f}_{k+1}(x, y) = \hat{f}_k(x, y) [k(-x, -y) \otimes g(x, y)/k(x, y) \otimes \hat{f}_k(x, y)] \tag{24}$$

where: \hat{f} is the estimated value of the degenerate function. After each iteration, the band that terminates when the MSE is a constant is obtained, and the likelihood probability is obtained as:

$$p(g|f) = \prod_x \frac{(f \otimes k)(x)^{g(x)} \exp\{-(f \otimes k)(x)\}}{g(x)} \tag{25}$$

where: k is PSF and $(f \otimes k)(x)$ is Poisson distribution. In order to obtain accurate target device characteristics, the likelihood probability $p(g|f)$ must be maximized, and the following energy equation must be minimized to obtain the maximum likelihood solution:

$$f^* = \arg \min_f E(f) \tag{26}$$

When the derivative of $E(f)$ and k is taken, the result of the de-jitter of the electronic imaging device is obtained, and the expression is:

$$f^{l+1} = f^l \left[k^* \otimes \frac{g}{f^* \otimes k} \right] \quad (27)$$

where: k^* is the adjoint matrix of k , and l is the number of iterations.

4 Analysis of Experimental Results

CMV300 of CMOS company is selected as the photoelectric platform sensor, and the effectiveness of this method is verified by comparing with the high-precision time jitter measurement method based on self reference source.

4.1 Experimental Indicators

- (a) Peak signal-to-noise ratio method PSNR. What it reflects is the peak signal-to-noise ratio of the reference image frame and the current image frame. PSNR can be used as a quality factor for assessing image quality and is defined as follows:

$$PSNR(s_1, s_0) = 10 \log \frac{255^2}{MSE(s_1, s_0)} \quad (28)$$

In the formula, PSNR is an index for evaluating the standard degree of stabilization algorithm. The larger the PSNR value, the more stable the electronic imaging device, and the better the de-shake effect. If the motion vector of the two frames is zero, the PSNR value should be infinite.

- (b) The mean square error MSE is; the sum of squared differences of each pixel between two frames of images. It reflects the speed of the image sequence change and the magnitude of the change. The smaller the MSE, the more stable the electronic imaging device and the better the de-shake effect. MSE is defined as follows:

$$MSE(S_1, S_0) = \frac{1}{M \cdot N} \sum_{i=1}^N \sum_{j=1}^M (S_1(i, j) - S_0(i, j))^2 \quad (29)$$

In the formula, $S_1(i, j)$ and $S_0(i, j)$ respectively represent the gray value of the pixel at the point (i, j) of the current frame and the reference frame after the image sequence is compensated, and M and N represent the pixel area of the current frame and the reference pixel frame. The smaller the value of $MSE(S_1, S_0)$ is, the higher the degree of overlap between the two images is. If the two images are completely overlapped, then $MSE(S_1, S_0)$ should be zero.

5 Analysis of Experimental Results

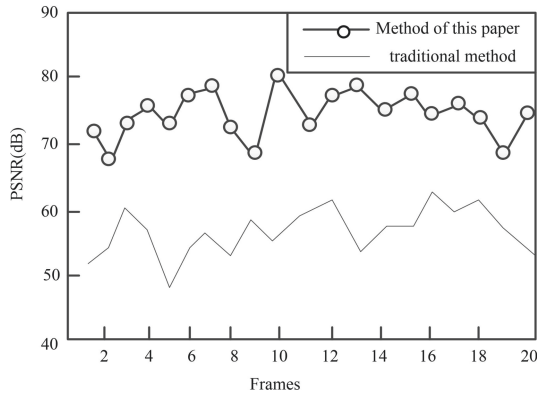


Fig. 1. PSNR comparative analysis

It can be seen from Fig. 1 that when the traditional method is used, the PSNR value is about 56.84 dB and the fluctuation is large. When the method in this paper is used for de-jitter processing, the PSNR value is about 72.64 dB, the fluctuation is small, and it is 15.8 higher than the traditional method. dB, indicating that the more stable the electronic imaging equipment adopts the method in this paper, the smaller the deviation, the better the de-jitter effect.

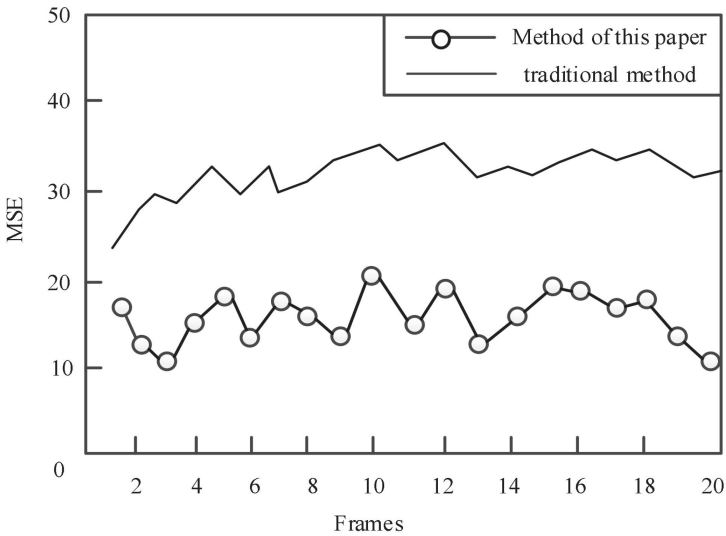


Fig. 2. Comparative analysis of mean square error MSE

It can be seen from Fig. 2 that when the traditional method is used, the MSE value is about 30.64 and the fluctuation is large. When the method in this paper is used for de-jitter processing, the MSE value is about 12.54, the fluctuation is small, and it is 18.1 lower than the traditional method. When the electronic imaging equipment adopts the method in this paper, the more stable and the smaller the deviation, the better the de-shake effect.

The experimental results show that the method in this paper compares with the traditional methods, and verifies the effectiveness of the de dithering method for electronic imaging equipment. The fluctuation of PSNR value and MSE value of this method is small, and the deviation is small. It shows that the de dithering effect of this method is better, and it can be effectively applied to the image blur problem caused by electronic imaging equipment in dynamic environment, It is of great significance to electronic imaging technology.

6 Conclusion

The article proposes an electronic imaging device de-shake method based on feature point matching. By acquiring device motion characteristics, using matching feature windows to achieve feature point matching of the motion path of the electronic imaging device, and determining and modifying the motion path according to the base function synthesis curve Curve characteristics, thereby optimizing the path estimation value, thereby improving the de-shake effect of the electronic imaging device. This method solves the problem of image blurring caused by the electronic imaging device in a dynamic environment to a certain extent. The results are obtained through experimental analysis. When the method in this paper is used for the de-jitter processing of electronic imaging equipment, the PSNR value is about 72.64 dB and the MSE value is about 12.54, which are better than traditional methods. However, due to the limitation of research conditions, the time-consuming situation of de-shake electronic imaging equipment needs to be further considered in future research, so as to enhance the efficiency of the de-shake method of electronic imaging equipment and improve the practical application effect of electronic imaging equipment.

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