# Noise removal algorithm for out-of-focus blurred images based on bilateral filtering

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**Abstract—The feature resolution of traditional methods for fuzzy image denoising is low, for the sake of improve the strepitus removal and investigation ability of defocused blurred night images, a strepitus removal algorithm based on bilateral filtering is suggested. The method include the following steps of: Building an out-of-focus blurred night scene image acquisition model with grid block feature matching of the out-of-focus blurred night scene image; Carrying out information enhancement processing of the out-of-focus blurred night scene image by adopting a high-resolution image detail feature enhancement technology; Collecting edge contour feature quantity of the out-of-focus blurred night scene image; Carrying out grid block feature matching design of the out-of-focus blurred night scene image by adopting a bilateral filtering information reconstruction technology; And building the gray-level histogram information location model of the out-of-focus blurred night scene image. Fuzzy pixel information fusion investigation method is used to collect gray features of defocused blurred night images. According to the feature collection results, bilateral filtering algorithm is used to automatically optimize the strepitus removal of defocused blurred night images. The simulation results show that the out-of-focus blurred night scene image using this method for machine learning has better strepitus removal performance, shorter time cost and higher export peak signal-to-strepitus proportion.**

**Keywords—Bilateral filtering, defocused blurred image, grayscale feature, removal, strepitus.**

## I. Introduction

WITH the development of out-of-focus blurred image processing technology, image information processing technology is used to analyze out-of-focus blurred night images, a feature sequence acquisition model of out-of-focus blurred night images is established, and image information structure feature analysis is carried out according to the feature distribution of out-of-focus blurred night images, so as to improve the investigation and feature analysis diagnostic capabilities of out-of-focus blurred night images [1]. The research on strepitus removal algorithms of related out-of-focus blurred night images has attracted great attention. The research on the strepitus removal of out-of-focus blurred night images is to use optimized image processing technology for fuzzy feature identification, establish a high-precision imaging model for the strepitus removal of out-of-focus blurred night images, and combine the fuzzy feature sequence analysis method to remove the strepitus of out-of-focus blurred night images [2].

Considering that the fuzzy image not only has low gray level of pixels, but also contains a lot of strepitus, this paper will study the brightness enhancement and strepitus removal of low illumination image at the same time. At present, image and video acquisition equipment is widely used in intelligent transportation, medical image, security monitoring and other fields, which has become an indispensable part of people's life. However, image in the acquisition, transmission, processing and other stages will inevitably introduce strepitus. Therefore, image denoising algorithm has become a research topic in the field of digital image processing. Traditional image denoising algorithms can be divided into two categories: spatial domain denoising and transform domain denoising. Bilateral filtering is an early data adaptive filtering, which considers the spatial distance and range distance of pixels, and uses the product of spatial Gaussian kernel and range kernel to determine the weight of pixels in the neighborhood. Due to the consider proportion of pixel range information, bilateral filtering has better edge preserving denoising characteristics. However, when the strepitus level in the image is high, the value of range kernel will be seriously affected, resulting in poor denoising effect. In view of the question that when the strepitus level in the original image is high, the bilateral filter can not detect the image edge better, Petschnigg *et al*. pointed out that the flash image with low strepitus level and rich detail information can be used to guide the process of the bilateral filter of the corresponding non flash image with high strepitus content. This method is called joint bilateral filter. Joint bilateral filtering further optimizes the performance of bilateral filtering. However, due to the need to use the same scene flash no flash image pair in the filtering process, joint bilateral filtering is limited in practical application. Clear and strepitusless image signal will show significant sparse representation features in a specific transform domain, and strepitus interference will lead to the weakening of sparse features of image. According to this observation, the denoising algorithm based on sparse representation of image super complete dictionary has become a new idea in the field of image denoising, and the learning dictionary is updated by SVD. Compared with the traditional transform domain denoising algorithm, the bilateral filtering algorithm can effectively adapt the texture details of the image while sparse representation of the image. Transform domain denoising method can better settle the question of smoothing figure details in spatial domain denoising method, but it also has some disadvantages, that is, it is easy to produce false signal and ringing effect. Due to the advantages and disadvantages of spatial domain and transform domain denoising, the current research on figure denoising algorithm is not limited to spatial domain or transform domain, and a series of excellent algorithms combining the two have emerged.

In traditional methods, the strepitus removal methods for defocused blurred night images mainly include texture feature analysis method, edge contour feature investigation method, fuzzy information reconstruction method and gray histogram register proportion method [3]. Reference [4] proposes a clear feature allocation and fuzzy recognition method for defocused blurred night images based on edge fuzzy feature collection, constructs a three-dimensional grid block feature matching model for defocused blurred night images based on uniform quantization feature collection, and combines the pixel sequence reconstruction method to carry out grid block feature matching, but this method has large time cost and poor feature resolution ability. Reference [5] proposes a multi-texture local mesh block feature matching and edge fuzzy recognition method based on wavelet multi-scale decomposition for defocused blurred night images, and combines the image filtering method to carry out mesh block feature matching processing for defocused blurred night images. The method has the questions of poor adaptability and low export pixel intensity. Reference [6] suggested that logistic discriminant method, as a well-known statistical method, has been successfully applied to many practical applications, including medical diagnosis and personal credit evaluation. The model is applied to the imbalance question, also known as skewness or rare class question, which is characterized by more instances of one class (negative class or majority class) than another class (positive class or minority class). Two basic measures of imbalance question, G-mean and F-measure, are studied, and two new cost functions, G-mean based measure (GM) and F-measure based measure (FM), are designed to supervise the corresponding parameters of logistic discriminant learning. Reference [7] suggested a robust nonnegative matrix decomposition method on manifold based on projection gradient method. The algorithm uses L21 norm to measure the quality of factorization and is insensitive to strepitus and outliers. The algorithm also makes use of the geometric structure of the data set and considers the local invariance. Manifold learning is combined with nonnegative matrix decomposition. The projection gradient method is used to obtain the update rules. The experimental results on multiple data sets and the comparison with other clustering algorithms prove the effectiveness of the algorithm. However, the feature resolution of the above method is low.

To settle the above questions, this paper proposes a strepitus removal algorithm for defocused blurred night images based on bilateral filtering. The off-focus blurred nightscape image acquisition model is constructed based on grid block feature matching of the off-focus blurred nightscape image, the information enhancement processing of the off-focus blurred nightscape image is carried out by using the high-resolution image detail feature enhancement technology, the gray histogram information location model of the off-focus blurred nightscape image is constructed, the gray feature collection of the off-focus blurred nightscape image is realized by using the fuzzy pixel information fusion investigation method, and the strepitus removal of the off-focus blurred nightscape image is realized. Finally, the simulation results show that compared with the literature method, this method has superior performance in improving the denoising performance of defocused blurred night scene image, short time overhead and high export peak signal-to-strepitus proportion.

## II. Basic Definitions

### A. Out-of-focus Fuzzy Night Image Acquisition Model

According to the correlation between image and strepitus, image strepitus can be divided into additive strepitus and multiplicative strepitus.

The additive strepitus itself is independent and independent of the image signal strength. Therefore, the image with additive strepitus can be regarded as the direct addition of strepitusless image signal and strepitus signal. This is also the most common strepitus model in the study of denoising.

Multiplicative strepitus is related to image signal and will change with the change of image signal. For example, the multiplicative strepitus caused by the change of the carrier carrying the pixel information will be affected by the modulation of the information itself. The strepitus in the point by point scanning image, the strepitus in the TV scanning grating and the film particle strepitus belong to this category.

In some cases, if the signal itself changes very little, the associated strepitus is also small. For the sake of deal with and analyze strepitus easily, it is often assumed that strepitus and signal are independent of each other, while multiplicative strepitus is regarded as additive strepitus approximately. According to the cause of formation, strepitus can be divided into thermal strepitus, flicker strepitus, emission strepitus and colored strepitus.

Thermal strepitus is the strepitus that guides the electric carrier to produce due to thermal disturbance. The distribution of thermal strepitus is consistent from zero frequency to a very high frequency range. This kind of strepitus is also called Gaussian strepitus because its spatial amplitude conforms to the Gaussian distribution; In addition, because its frequency covers the whole spectrum, it is also called white strepitus.

Flicker strepitus is caused by current movement. Because the electron or charge flow is not a perfect continuous process, their randomness will produce an AC component that is difficult to quantify and measure, which is the source of strepitus. This kind of strepitus often has a spectrum that is inversely proportional to 1 / F frequency, so it is also called 1/f strepitus.

Emission strepitus is also a kind of strepitus with Gaussian distribution, which is produced by the current non-uniform flow. It can be studied and analyzed by the principles of statistics and probability.

Colored strepitus refers to broadband strepitus with nonwhite spectrum. Compared with white strepitus, colored strepitus accounts for a large proportion in the medium and low frequency components. The strepitus produced by moving cars and rotating fans is typical colored strepitus. An example is shown in Fig. 1.

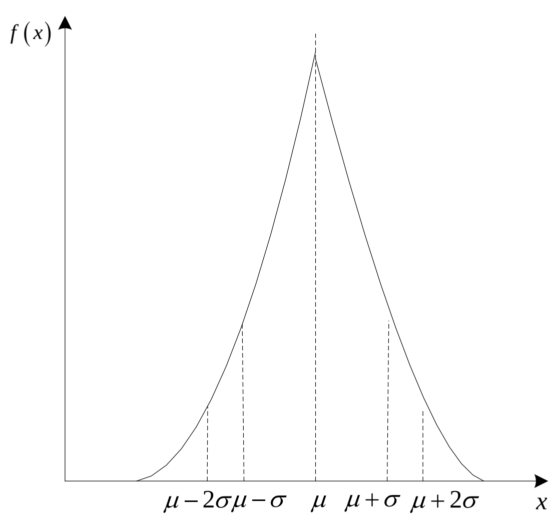



Fig. 1 probability density function of Gaussian strepitus

Image denoising algorithms can be classified from different perspectives. It can be divided into two kinds of processing methods: spatial domain and transform domain. The former is to process the image directly in the space of the image itself; The latter is to transform the image into the transform domain, using the characteristics of the transform domain for processing, and finally transform it back to the space domain. According to different computing properties, the algorithm can be divided into linear denoising algorithm and nonlinear denoising algorithm. The spatial domain denoising algorithm is based on the space of the image, using the filter (also known as template, window) to directly act on the image itself. The filter consists of a template window (usually a smaller rectangle) and predefined proportions on the pixels covered by the window. In image denoising, the filter center accesses each pixel in the image in turn, calculates the pixel value surrounded by the window through predefined proportions, and obtains a new pixel value. The new value is modified and replaced according to some rules. After the filter accesses all pixels of the image, the strepitus image is produced and strepitus. The end of the strepitus. If the proportion of denoising algorithm on noisy image is linear, it is called linear denoising algorithm, otherwise it is nonlinear. Fig. 2 spatial domain denoising.

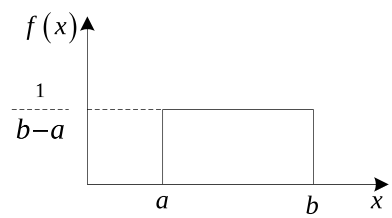



Fig. 2 probability density function of uniform strepitus

Like the classical Gaussian filter, the bilateral filter only uses the local weighted average, the difference is that the bilateral filter can use the spatial proximity information (geometric distance) and gray similarity information of the pixels in the neighborhood at the same time, so that the algorithm can better save the edge of the image, effectively smooth out the strepitus, and obtain better image enhancement effect. With the rapid development and popularization of the research and application of bilateral filter, it can be seen everywhere in the application of image processing. It has been widely used in many fields, and has been greatly developed in theory and application. In practical applications, bilateral filters are widely used in image proportion. Although the research on the application and performance of bilateral filters has made great achievements, the bilateral filters belong to the non-linear filtering technology, so the linear convolution proportion of image cannot be realized. Bilateral filtering algorithm can only be realized by calculating point by point, which makes bilateral filtering very time-consuming. When the spatial standard deviation (T) of the two-sided filter is large, the mask window width will also increase, and the calculation amount of the filter will increase proportionally. The original two-sided filter usually needs tens of seconds or even minutes to smooth the image of one million pixels, while the Gaussian filter can process and export the image in real time. Therefore, compared with most linear filters, the computation speed of bilateral filters is too slow. With the increasing demand for image clarity, the resolution of image is also increasing, which undoubtedly greatly increases the proportion time of bilateral filter, which to a large extent limits the application efficiency of bilateral filter. How to realize fast bilateral filter algorithm and reduce the calculation time is of great significance.

For the sake of realize the optimal design for strepitus removal of defocused blurred night images, firstly, a three-dimensional visual information acquisition model of defocused blurred night images is constructed, and defocused blurred night images are acquired by combining a grid block feature matching method, and spatial visual characteristics of defocused blurred night images are reconstructed by adopting a multi-dimensional three-dimensional tracking and information sampling method, and spatial visual characteristics of defocused blurred night images are distributed acquired by combining a point scanning tracking technology, the obtained three-dimensional vision sampling image of the defocused blurred night scene image space is $s(X,Y)$, and the distributed information sampling export of the defocused blurred night scene image is obtained by adopting a fuzzy information sampling method as following:

$$Ncut(A,B)=\frac{cut(A,B)}{assoc(A,V)}+\frac{cut(A,B)}{assoc(B,V)} \tag{1}$$

Among them, $assoc(A,V)$ is a subset of pixels of defocused blurred night figures under machine vision. A binary model (Dominant LBP, DLBP) for spatial vision fusion of defocused blurred night figures is established. The template feature matching method is adopted to reconstruct the features of the collected defocused blurred night figures, and the spatial feature matching export of the defocused blurred night figures is obtained as following:

$$W_u u(a,b_m)=\frac{1}{\sqrt{a}}\int_{-aT/2+b_m}^{T/2}\left|\frac{1}{\sqrt{T}}\right|^2 dt=\frac{1}{\sqrt{aT}}(\frac{T}{2}+\frac{aT}{2}-b_m) \tag{2}$$

In the pixel distribution space, the gray level of the defocus fuzzy night scene figure is calculated, and the multi-layer segmentation model of the defocus fuzzy night scene figure is established in the local area of the 4×4 sub-block, which is described as following:

$$\begin{aligned} d_{i+1}&=2F(x_{i+1}+\frac{1}{2},y_i+2)\\ &=\begin{cases} 2[\Delta x(y_i+2)-\Delta y(x_{i,r}+\frac{1}{2}-\Delta xB)] & d_i\le 0\\ 2[\Delta x(y_i+2)-\Delta y(x_{i,r}+1+\frac{1}{2}-\Delta xB)] & d_i>0 \end{cases} \end{aligned} \tag{3}$$

In the blurred area, the CT imaging technology is adopted for figure acquisition, and the obtained defocused blurred night scene figure acquisition export is as following:

$$\begin{aligned} P\left(y_{w_3}\mid x_{w_3},\theta,\beta\right)&\propto P\left(y_{w_3}\mid x_{w_3},\theta\right)\left(y_{w_3}\mid\beta_i\right)\\ &\propto\prod_{k=1}^{K}\alpha_k\frac{1}{\sqrt{2\pi\sigma_k^2}}\exp\left\{-\frac{\left(x_i-\mu_k\right)^2}{2\sigma_k^2}\right\}\cdot\frac{1}{Z\left(\beta_i\right)}\exp\left(-\sum_{c\subset C}V_c(Y,\beta_i)\right)\\ &\propto\prod_{k=1}^{K}\frac{\alpha_k}{Z\left(\beta_i\right)\sqrt{2\pi\sigma_k^2}}\cdot\exp\left\{-\left[\sum_{k=1}^{K}\frac{\left(x_i-\mu_k\right)^2}{2\sigma_k^2}+\sum_{c\subset C}V_c(Y,\beta_i)\right]\right\} \end{aligned} \tag{4}$$

Carrying out grid segmentation on each template in the visual space of the defocused blurred night scene image, carrying out local correlation frame binary reconstruction in an m*n region, and building a fuzzy information reconstruction model of the defocused blurred night scene image, and obtaining the regional characteristic distribution points of the defocused blurred night scene image as following:

$$J(x)=\frac{I(x)-A}{\max(t(x),t_0)}+A \tag{5}$$

Among them, the structural similarity of out-of-focus blurred night images is expressed, template matching is carried out in the 3*3 neighborhood structure of the images, and spatial segmentation and information enhancement processing are carried out through the acquisition results of out-of-focus blurred night images [8].

### *B. Image Information Enhancement*

Image is an indispensable information source in human production and life. With the development of science and technology, the application of digital image has penetrated into all aspects of human beings, playing an increasingly important role. High quality digital image is the foundation of image research and application. However, due to the strepitus pollution of environment, electronics, artificial and so on, the image quality is reduced in the process of image capture, storage, transmission and conversion, resulting in the error and incompleteness of the acquired image information. Digital image denoising plays an important role in many fields of science and engineering, such as medical and astronomical imaging, movie image proportion, image and video coding. Proportion of noisy images is usually an ill posed inverse question, which needs to be settled by selecting appropriate regular terms.

The regularization parameters play an important role in balancing the regular term and the data fidelity term in the functional model. When the regularization parameters are large, the data fidelity plays a leading role, and the solution of the model is closer to the initial value; When the regularization parameters are small, the regularization plays a leading role, and the processed image is smoother. According to whether the prior knowledge of image strepitus is needed or not, the selection methods of regularization parameters can be roughly divided into two categories: One is based on the prior knowledge, such as the method based on image signal-to-strepitus proportion and the method based on image strepitus variance. The other is the method without prior knowledge, such as generalized cross validation and curve method. An ideal situation is to be able to find a direction that can make the objective function value drop the fastest, and then start from the initial value, along the best direction to quickly drop, in the shortest possible time to reach the minimum point.

Strepitus is a kind of signal that people don't need, or a variety of factors that affect the receiving or understanding of system sensors. According to the source of strepitus, strepitus can be divided into two categories: strepitus and natural strepitus. Only natural strepitus is discussed here. The natural strepitus in the system also comes from many aspects. There are strepitus from electronic components and optical components. The strepitus of electronic circuit or equipment composed of free electronic components can be collectively referred to as electrical strepitus. The strepitus in the optical phenomenon produced by optical components is called optical strepitus. The most essential difference between the two kinds of strepitus is that electrical strepitus is generally considered as additive strepitus, which always exists and has nothing to do with the size of useful signals. It is superimposed on the original signal. The optical strepitus is mostly multiplicative strepitus, which can modulate the signal and change with the size of the signal. When the gray changes and strepitus of two-dimensional image are very small, multiplicative strepitus can be approximated as additive strepitus. Therefore, the strepitus discussed in this paper refers to additive strepitus. In the process of natural image denoising, because additive strepitus is independent of image, it is usually assumed that image and strepitus are independent of each other in Fig. 3.

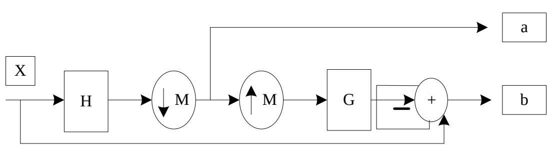



Fig. 3 multi scale reconstruction process of image

The traditional two-sided filtering algorithm is a denoising algorithm with edge preserving effect, which takes into account the Euclidean distance and gray value difference of the weighted pixels. However, it also has some shortcomings:

1) It is not easy to implement the hardware by using exponential floating-point proportion;

2) The filter parameters are set according to the experience value, so it is impossible to realize the effective control. For the sake of settle these questions effectively, scholars put forward many different improvement strategies.

With the continuous research and progress of image processing technology, more and more new denoising algorithms are suggested. Nonlinear methods are widely used in various fields of image processing because they are more consistent with human visual characteristics (spatial filtering characteristics, time characteristics, brightness and chroma characteristics). At the same time, the non-linear signal processing conference organized by the non-linear signal processing research group every two years promotes the application and development of non-linear methods in the field of image processing. The continued fraction, as a key technique in the study of nonlinear proportion approximation, naturally becomes the first choice in the study of nonlinear numerical questions. The knowledge of interpolation is used in image zooming, image reconstruction and image proportion. The continued fraction proportion interpolation function has a very important position in the field of image processing because of its high accuracy of approximation and simple calculation.

The bilateral filtering information reconstruction technology is adopted to carry out the grid block feature matching design of the defocused blurred night scene image, the vectorization set of the visual feature distribution of the defocused blurred night scene image is calculated [9], and the quantization feature distribution set of the region segmentation of the defocused blurred night scene image is as following:

$$w(i,j) = \frac{1}{Z(i)}\exp\left(-\frac{d(i,j)}{h^2}\right) \tag{6}$$

wherein, $Z(i) = \sum_{j\in\Omega}\exp\left(-\frac{d(i,j)}{h^2}\right)$ is a spatial visual gradient feature of the defocused blurred night scene image, an edge contour feature quantity of the defocused blurred night scene image is collected, a bilateral filtering information reconstruction technology is adopted to carry out grid blocking feature matching design of the defocused blurred night scene image, gradient mode features of the defocused blurred night scene image are defined, a unit moving scale correlation allocation method is adopted to carry out grid blocking feature matching of the defocused blurred night scene image space, gradient mode feature collection is carried out, and the gradient mode feature collection is carried out in a fuzzy region, using block fusion processing, gradient mode reconstruction and information fusion are carried out on the defocused blurred night scene image [10], and Laplacian operator is used to detect the image edge to obtain the gradient mode characteristics of the blurred region of the defocused blurred night scene image:

$$\min_c\left(\min_{y\in\Omega(x)}\left(\frac{I^c(y)}{A^c}\right)\right) = \tilde{t}(x)\min_c\left(\min_{y\in\Omega(x)}\left(\frac{J^c(y)}{A^c}\right)\right) + (1-\tilde{t}(x)) \tag{7}$$

where, $\tilde{t}(x)$ is the matching set of image frame feature points, $A^c$ is the statistical feature quantity of spatial pixels of the defocused blurred night scene image, $I^c(y)$ is the edge information intensity value of the I-th feature sampling point of the image, the image is regarded as a weighted undirected graph, $J(x)t(x)$ is set as the feature point to be added to the edge pixel set of the frame image, and the feature points of spatial sampling of the defocused blurred night scene image are obtained as following:

$$bnr_\beta\left(X\right) = R_\beta X - R_\beta X_1 \tag{8}$$

Building a high-precision grid block feature matching model of the defocused blurred night scene image, and obtaining pixel values of spatial vision distribution of the defocused blurred night scene image as following:

$$w\left(d_{ij}\right) = f\left(\left|x_i - x_j\right|\right) = \frac{1}{\sqrt{2\pi}}\exp\left\{\frac{\left(x_i - x_j\right)^2}{2}\right\} \tag{9}$$

The method include the following steps of: building a similarity characteristic resolution model of the defocused blurred night scene image, combining a pixel distribution matrix to carry out spatial visual reconstruction of the defocused blurred night scene image, obtaining scene coordinates in a region pixel distribution interval [11], carrying out segmented region grid and block characteristic matching according to spatial rotation and posture adjustment of the defocused blurred night scene image, adding characteristic points into the reconstructed scene, collecting edge contour characteristic quantity and enhancing information of the defocused blurred night scene image, and exporting pixel values as following:

$$\beta_i = \exp\left\{-\frac{\left|x_i - x_j\right|^2}{2\sigma^2}\right\}\frac{1}{\operatorname{dist}\left(x_i, x_j\right)} \tag{10}$$

Based on the above analysis, a multi-layer grid region location model of defocused blurred nightscape images is constructed, which is matched by grid block features of defocused blurred nightscape images. The information enhancement processing of defocused blurred nightscape images is carried out by using high-resolution image detail feature enhancement technology [12].

## III. Optimization Of Strepitus Removal Algorithm For Out-of-focus Blurred Night Images

### *A. Edge Contour Feature Collection of Out-of-focus Blurred Night Image*

The final receiving unit of image is human eye, and the final service object of image denoising and image enhancement is human subjective vision. Therefore, the subjective evaluation of image is an important basis for judging the performance of filtering cry. The subjective evaluation of image is to evaluate the quality of image by observing the image by human, and then get the evaluation result by statistical average. On the basis of the above-mentioned construction of the out-of-focus blurred nightscape image acquisition model with grid block feature matching and the information enhancement processing of the out-of-focus blurred nightscape image using high-resolution image detail feature enhancement technology, the optimal design for strepitus removal of the out-of-focus blurred nightscape image is carried out, and the out-of-focus blurred nightscape image strepitus removal algorithm based on bilateral filtering is suggested in this paper. The method include the following steps of: collecting the edge contour feature quantity of the defocused blurred night scene image, carrying out grid block feature matching design of the defocused blurred night scene image by adopting a bilateral filtering information reconstruction technology, carrying out spatial visual reconstruction of the defocused blurred night scene image by combining a template matching method, carrying out block matching of spatial visual features of the defocused blurred night scene image by adopting a multifractal technology, carrying out correlation feature matching on detail information with different resolutions, and obtaining similarity feature quantity of the defocused blurred night scene image space by adopting a multilevel and multidirectional decomposition method as following:

$$s(k) = \phi \cdot s(k-1) + w(k) \tag{11}$$

where:

$$\phi = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}, \quad w(k) = \begin{pmatrix} N(0,\sigma_{\theta(k)}) \\ 0 \\ N(0,\sigma_{x(k)}) \\ 0 \\ N(0,\sigma_{y(k)}) \end{pmatrix} \tag{12}$$

Collecting the spatial visual feature distribution value of the defocused blurred night scene image, obtaining the R, G and B components of the image by adopting an RGB decomposition method [13], wherein the matching values of the spatial visual three-dimensional reconstruction template of the defocused blurred night scene image are $A_R$, $A_G$, $A_{\mathbf{B}}$ and $W_R$, $W_G$, $W_B$, and obtaining the feature collection export of the defocused blurred night scene image in the feature template m*n based on a Gaussian mixture model as following:

$$E\left[f\left(\theta, k\right)\right] = 0, \forall \theta \in \left[-\pi, \pi\right], \forall k \in Z \tag{13}$$

Combining with the joint sparse structure feature decomposition method, the adaptive fusion and optimal segmentation processing of the defocused blurred night scene image are carried out, and the multi-layer spatial structure grid block feature matching and fusion clustering of the defocused blurred night scene image are carried out according to the feature segmentation result, so that the information enhancement and visual information feature collection of the defocused blurred night scene image are realized, and the calculation formula of segmentation export is as following:

$$S_{i,j}\left(t\right) = \frac{p_{i,j}\left(t\right) - sp_{i,j}\left(t\right)}{p_{i,j}\left(t\right)} \tag{14}$$

$$T_{i,j}\left(t\right) = \frac{\left|p_{i,j}\left(t\right) - \Delta p\left(t\right)\right|}{p_{i,j}\left(t\right)} \tag{15}$$

$$U_{i,j}\left(t\right) = \exp\left[-b\left[z_i\left(t\right) - z_j\left(t\right)\right]^2\right] \tag{16}$$

Among them, $p_{i,j}\left(t\right)$ is the displacement characteristic of defocused blurred night image at time t, is the exchange fitting function, $sp_{i,j}\left(t\right)$ is the reference value of standard defocused blurred night image, $z_i\left(t\right)$, $z_j\left(t\right)$ is the feature export of similarity defocused blurred night image respectively. According to the above analysis, the edge contour feature quantity of defocused blurred night scene image is collected, and machine learning and optimization are carried out according to the feature collection result [14].

### *B. Machine Learning Optimization*

A 4×4 sub-block segmentation model is used for spatial visual rotation and feature collection of defocused blurred night images, adaptive optimization is carried out in the three-dimensional distribution area of the defocused blurred night images, block feature matching method is adopted to carry out correlation frame sampling on the original defocused blurred night images, quantitative feature coding method is adopted to carry out coding design of the defocused blurred night images in the D-dimensional space, bilateral filtering algorithm is adopted to carry out adaptive proportion and optimization of the defocused blurred night images, strepitus removal of the defocused blurred night images is obtained [15, 16], and proportion export is as following:

$$u(x,y;t)=G(x,y;t) \tag{17}$$

$$p(x,t)=\lim_{\Delta x\to 0}[\sigma\frac{u-(u+\Delta u)}{\Delta x}]=-\sigma\frac{\partial u(x,t)}{\partial x} \tag{18}$$

wherein, $\Delta u$ is a pixel point with local correlation in a defocus blurred image frame, $\sigma$ is a horizontal difference characteristic quantity of that defocus blurred night scene image, an adaptive machine learning optimization model of the defocus blurred image is obtained in an $A_g$ region, corner point investigation of the defocus blurred night scene image is performed in a gradient direction, strepitus removal of the defocus blurred night scene image is realized by adopting a fuzzy pixel information fusion investigation method, and the export is as following:

$$\begin{cases} x=R\sin\eta\cos\phi & 0\le\phi\le 2\pi \\ y=R\sin\eta\sin\phi & 0\le\eta\le\pi \\ z=R\cos\eta & R=D/2 \end{cases} \tag{19}$$

where, S represents the edge brightness of the defocused blurred night image, $\phi$ represents the sparse feature component, $R$ represents the template matching coefficient of the defocused blurred night image, and X represents the edge blurred pixel set. To sum up, fuzzy pixel information fusion investigation method is used to collect gray features of defocused blurred night images. According to the feature collection results of defocused blurred images, bilateral filtering algorithm is used to automatically optimize strepitus removal of defocused blurred night images and improve image proportion accuracy.

## IV. Simulation Experiment And Result Analysis

For the sake of verify the application performance of the method in the proportion of defocused blurred night images, a simulation experiment is carried out. The experiment is designed by MATLAB. The images used in the experiment came from the image sharing website Flickr. The set of pixels sampled from defocused blurred night images is 150 × 150, and 100 pixels are randomly sampled from each defocused blurred night image. Superimpose Gaussian white noise with zero mean on the original image. The proportion step number of defocused blurred image denoising machine learning is 120, the step length of adaptive proportion is 20, and the gradient descent rate of grid block feature matching is 0.45. The characteristic quantization coefficient of the edge evolution of the defocused blurred image is 0.52. According to the above simulation parameter settings, the defocused blurred night scene image is registered, and the original image is obtained as shown in Fig. 4.

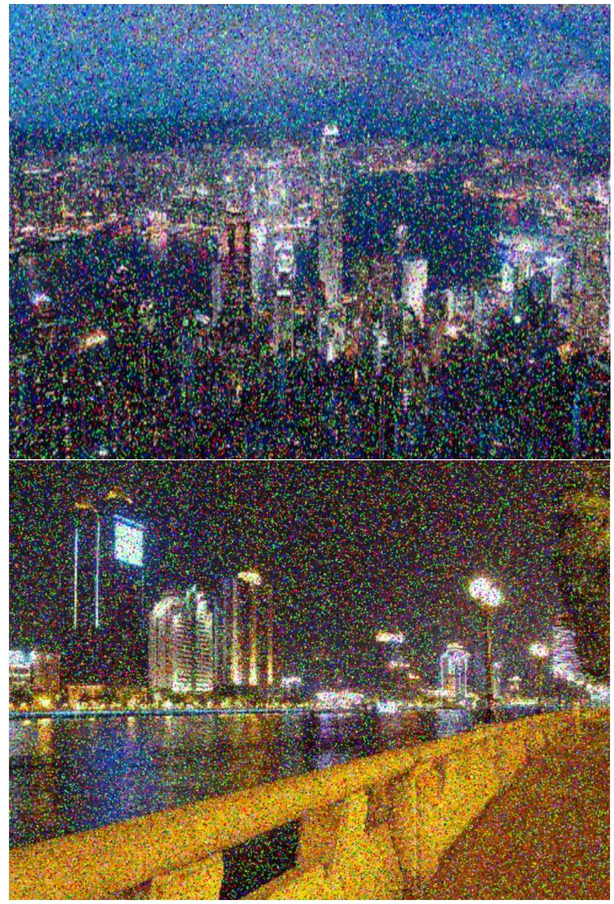


Fig. 4 original defocused blurred night scene image

Taking the image of Fig. 4 as input, the defocus blurred night scene image proportion is carried out, the edge contour feature quantity of the defocus blurred night scene image is collected, the bilateral filtering information reconstruction technology is adopted to carry out the grid block feature matching design of the defocus blurred night scene image, and the defocus blurred image denoising export is obtained as shown in Fig. 5.

Fig. 5 registration export of defocused blurred night images

Fig. 2 shows that this method can effectively remove the strepitus of out of focus blurred night scene image and improve the automatic optimization ability of image strepitus removal. This is because this method uses fuzzy pixel information fusion investigation method to collect the gray features of out of focus fuzzy night scene image. According to the results of feature collection, the bilateral filtering algorithm is used to automatically optimize the strepitus removal of defocused blurred night scene image. The time cost of different methods for defocus blurred image registproportionn is tested. The method in this paper is compared with reference [4] and reference [5], and the comparison results are shown in Table I. The analysis of Table I shows that the method takes a short time to remove the defocus blurred image strepitus.

Table I. Comparison of time expenses for strepitus removal of out-of-focus blurred images (Unit: ms)

| Image pixel | This method | Reference [4] | Reference [5] |
|---|---|---|---|
| 100 | 2.544 | 12.546 | 15.776 |
| 300 | 5.567 | 32.578 | 23.655 |
| 500 | 7.634 | 36.456 | 35.546 |
| 700 | 8.545 | 65.435 | 42.789 |

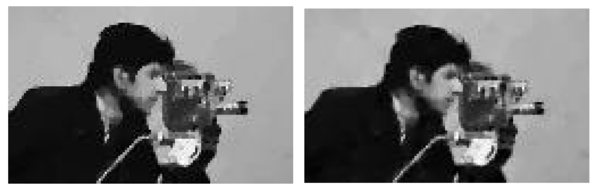
The peak signal-to-strepitus proportion of the test export is shown in Table II. Table II shows that the suggested method can effectively improve the peak signal-to-strepitus proportion of out-of-focus blurred night image proportion and improve the imaging quality of out-of-focus blurred images. This is because this method uses bilateral filtering information reconstruction technology to design lattice feature matching for out of focus blurred night scene image.

Table II. Peak signal-to-strepitus proportion comparison (Unit: dB)

| Image pixel | This method | Reference [4] | Reference [5] |
|---|---|---|---|
| 100 | 34.6 | 21.7 | 25.4 |
| 300 | 45.3 | 36.3 | 36.2 |
| 500 | 54.4 | 46.4 | 43.6 |
| 700 | 67.7 | 48.8 | 49.7 |

By extending the solution driven adaptive total variation regularization to the solution driven adaptive generalized total variation regularization model, it is shown that the adaptability is improved. This is because this method uses high-resolution image detail feature enhancement technology to enhance the information of out of focus blurred night scene image, and collects the edge contour feature of out of focus blurred night scene image. For this purpose, the camera image with zero mean and standard deviation of 0.1 strepitus is taken as the test object, and the experiment of image denoising and blur removing is carried out in Fig. 6.

(a)



(b) (c)

Fig. 6 test results of full variation image de blur effect

Because the pixels on the edge of the image and the pixels polluted by impulse strepitus are different from the neighboring pixels, they are easy to interfere with each other in strepitus investigation. However, in the natural image, the arrangement of edge pixels generally has a strong directionality, which provides a breakthrough to distinguish the two. According to the similarity with the original image, we can see that the generalized total variation regularization algorithm improves the recovery results.

## V. Discussion

At present, image and video acquisition equipment is widely used in intelligent transportation, medical image, safety monitoring and other fields, and has become an indispensable part of people's life. An out of focus fuzzy image denoising algorithm based on bilateral filtering is proposed. The main work of this paper is as follows:

(1) The acquisition model of out of focus blurred night scene image is established, and the new value is modified and replaced according to some rules. After the filter processes all pixels of the image, a fringe image is generated and the fringe image is.

(2) The three-dimensional visual information acquisition model of defocus blurred night scene image is established, the defocus blurred night scene image is obtained by combining the grid block feature matching method, the spatial visual features of defocus blurred night scene image are reconstructed by multi-dimensional three-dimensional tracking and information sampling method, and the spatial visual feature distribution of defocus blurred night scene image is obtained by combining the point scanning tracking technology. The three-dimensional visual sampling image of defocus blurred night scene image space is obtained, and the distributed information sampling

output of defocus blurred night scene image is obtained by fuzzy information sampling method.

(3) The grid feature matching design of defocused blurred night scene image is carried out by using bilateral filtering information reconstruction technology, and the vector set of visual feature distribution of defocused blurred night scene image is calculated.

(4) The high-resolution image detail feature enhancement technology is used to enhance the information of out of focus blurred night scene image, the optimal design of fringe removal is carried out for out of focus blurred night scene image, and a fringe removal algorithm of out of focus blurred night scene image based on bilateral filtering is proposed. The experimental results show that the proposed method can effectively improve the peak signal-to-noise ratio of out of focus blurred night scene image, improve the imaging quality of out of focus blurred image, and extend the self-adaptive total variation regularization of de driving to the self-adaptive generalized total variation regularization model of de driving, so as to improve the adaptability of the model.

## VI. Conclusion

In this paper, a strepitus removal algorithm based on bilateral filtering is suggested. An out-of-focus blurred night scene image acquisition model with grid block feature matching of the out-of-focus blurred night scene image is constructed, information enhancement processing of the out-of-focus blurred night scene image by adopting a high-resolution image detail feature enhancement technology is carried out, edge contour feature quantity of the out-of-focus blurred night scene image is collected. The grid block feature matching design of the out-of-focus blurred night scene image by adopting a bilateral filtering information reconstruction technology is carried out. The gray-level histogram information location model of the out-of-focus blurred night scene image obtained. Fuzzy pixel information fusion investigation method is used to collect gray features of defocused blurred night images. According to the feature collection results, bilateral filtering algorithm is used to automatically optimize the strepitus removal of defocused blurred night images. The simulation results show that the out-of-focus blurred night scene image using this method for machine learning has better strepitus removal performance, shorter time cost and higher export peak signal-to-strepitus proportion. This method has good application value in fuzzy image strepitus reduction.

Bilateral filtering technology is still in the process of continuous development and improvement. In combination with the content of this paper, there are some areas to be improved. The next work can be further developed in the following aspects: Continue to design new bilateral filtering fast algorithm and optimize the performance of this paper and the existing fast algorithm, and improve the robustness, As soon as the original image processing function, filtering accuracy and performance are retained, the fast algorithm will continue to reduce the computational complexity and improve the efficiency. The theory and idea of bilateral fast algorithm are applied to other filters, so that other filters can also achieve the level of real-time calculation. In the future development, the resolution of out of focus blurred night scene image is further improved, and advanced technology is applied to the fringe suppression of blurred image. Draw a more concise link map, optimize the edge contour feature quantity, use advanced acquisition technology to obtain out of focus blurred image data, further optimize the information sampling output, replan the spatial visual feature distribution, and improve the image imaging quality.

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Wenfang Zhang collected the samples, analysed the data. Chi Xu conducted the experiments and analysed the results. All authors discussed the results and wrote the manuscript.