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The Algorithm of the Textures Anti-Aliasing in the Virtual Images De-Blurring Methods Area Based Model

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Abstract: In resaerch the algorithms of textures anti-aliasing of the area based virtual model using low frequencies filters and algorithms of de-blurring in particular Lucie-Richardso's algorithm, algorithms based on the Wiener's filter, Tikhonov's filter and the inverse filter are considered.

Key words: Anti-aliasing, low frequencies filters, de-blurring, Lucie-Richardson's algorithm, Wiener's filter, Tikhonov's filter, inverse filter

INTRODUCTION

Improvement of displaying quality of the area virtual model is one of important problems of image processing. The pilot of the aircraft (the plane or the helicopter) needs to obtain the most objective information on a situation behind a board. These data are especially important under the poor visibility conditions (smoke, settling, fog, low illuminating intensity including at night). For formation of the image on the display of the control system of the aircraft realizing a functional of support of a decision making in the course of piloting specialized systems of the combined vision are created. The image turns out by combination of the data obtained from Television (TV) and Thermovision (TPV) cameras mounted on the aircraft and the Area Virtual Model (AVM) received according to the digital district map (Sing *et al*., 2005). In the course of development of the automatic solution of a problem of combination there is a number of problems, one of which is serrated edges appearing on borders of the linear and polygonal objects (so-called "comb") at display of the area virtual model when flying at low heights. "Comb" essentially prevents further automatic combination of the images received from the cameras mounted on the aircraft and the area virtual model. Therefore, before combination it is necessary to smooth borders of objects on AVM for the purpose of eliminating "comb". At the moment for the solution of this task the following approaches are used:

- Excess selection of smoothing or super sampling (English Super Sample Anti-Aliasing, SSAA): a lack of an algorithm is the fact that it is necessary to count all scene entirely that gives larger load of video memory and its tire
- Multi-sampling: a shortcoming are high requirements to memory and time of processing

Thus, for the solution of a problem of improvement of the AVM display as a part of the systems of the combined vision working in real time and established on perspective models of the planes and helicopters released by the enterprises of the Russian Federation, use of the existing algorithms is not possible and the algorithm, the free from the listed shortcomings which description is provided in the real work is necessary (Wee *et al*., 2002).

MATERIALS AND METHODS

Algorithm of the AVM textures anti-aliasing: This algorithm consists of the following stages: application to the image of the filter of low frequencies, is a consequence of what the strong degradation of the AVM image.

After application to the image of the Low Frequencies Filter (LFF), all lines smooth out, but the main information on objects on the image is not lost. All information is just redistributed under some law and can be restored, except for shallow objects and thin lines which are not essential to further combination. De-blurring (English de-blurring diffuseness elimination): restitution of a clear boundary of indistinct objects.

After by means of LFF thin lines and shallow objects were almost eliminated from the image, it is necessary to restore a clear boundary of large objects by means of this or that algorithm of de-blurring. Using de-blurring algorithm, it is possible to assume that the image was washed away by the distorting function based on Gauss LFF (Nielsen, 2004).

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Low frequencies filters: Low frequencies filters reduce amplitudes of high-pitched components in an image range are a consequence of what:

- Smoothing of contours on the image
- Diffuseness of the image
- Partial or the complete of eliminating pulse hindrances

The following low frequencies filters are the most popular:

- The homogeneous normalized filters
- Filter of Gauss
- Median filter

The filter of Gauss is based on use of two dimensional function of Gauss:

$$g(x,y)=\frac{1}{2\pi\sigma^2}e^{\frac{-x^2+y^2}{2\sigma^2}} \quad (1)$$

Parameter σ in Eq. 1 influences sharpness of peak of function (than less absolute value of parameter, subjects peak more sharply and vice versa).

On values of function of Gauss are the center To the filter, at the same time the center of a core coincides with function peak. The filter of Gauss keeps the dominating influence of the pixel getting to the center of a core but at the same time considers values of the next pixels that leads to slight degradation of the initial image.

The median filter falls into to a class of the space filters which are not described by a convolution core. Values of counting in a window of the filter are sorted in ascending order of (decrease) and the value which is in the middle of the ordered list enters on a filter exit. In case of an even number of counting in a window output value of the filter to equally mean value of two counting in the middle of the ordered list. The window moves along the filtered signal and calculation repeat.

The central element is replaced with a median of all elements of the image in a window. A median of the discrete sequence a_1, a_2, a_3 … for odd n is that element for which exist (n-1)/2 of elements, smaller or equal to it in size and (n-1)/2 larger or equal to it in size.

RESULTS AND DISCUSSION

De-blurring: Operation of application of the distorting function to other function (to the image, in this case) is called convolution ((English) convolution), i.e., some area of the initial image is turned in one pixel of the distorted image. Application of the distorting function h to the image f can be described as:

$$f=\left[f_{xy}\right];\ x=1',M;\ y=1',N$$

$$h=\left[f_{\mu k}\right];\mu=1',m;k=1',n$$

$$g(x,y)=h*f(x,y)=\sum_{i=-a}^{a}\sum_{j=-b}^{b}h(a+i+1,b+j+1)f(x+i,y+j) \quad (2)$$

$$a=\frac{m-1}{2};b=\frac{n-1}{2}$$

Operation, inverse to convolution, is called de-convolution. There is a theorem of a parcel which says that operation of convolution in a spatial domain is equivalent to routine multiplication in the frequencies area (and multiplication bit-by-bit but not matrix). Respectively, operation, inverse a parcel, is equivalent to multiplication in the frequencies area:

$$h*f(x,y)\leftrightarrow H(u,v)F(u,v)$$

where, H(u, v), F(u, v) are Fourier images of the corresponding functions. Therefore, process of distortion (Eq. 2) can be written down in a look:

$$G(u,v)=H(u,v)F(u,v)$$

The problem of recovery of the distorted image consists in finding of the best approximation f'(x, y) initial image.

Inverse filter: The most prime way of restitution is the inverse filtration which assumes receiving assessment $\hat{F}(u,v)$ Fourier transformations of the initial image division of Fourier-transformations of the distorted image on the frequencies representation of the distorting function:

$$\hat{F}(u,v)=\frac{G(u,v)}{H(u,v)}$$

where division is understood as bit-by-bit.

Wiener's filter: Development of a method of an inverse filtration is the Wiener's filter (Gonsalez and Woods, 2005) which is based on the analysis of the image and noise as casual processes. The task is set as follows: to find such assessment $\hat{f}$ for the undistorted image f that mean squared deviations of these sizes from each other was minimum. It is supposed that the following conditions are satisfied:

- Noise and the undistorted image are not correlated among themselves
- Either noise or the undistorted image have zero mean value
- Assessment linearly depends on the distorted image

When performing these conditions the minimum of root mean square deviation is reached on function which is set in the frequencies area by expression:

$$\hat{F}(u,v) = \left(\frac{1}{H(u,v)} \frac{|H(u,v)|^2}{|H(u,v)|^2 + S_\eta(u,v) / S_f(u,v)} \right) G(u,v) \quad (3)$$

Where:

H (u, v) = The distorting function (its frequencies representation)
H (u, v) = Complex interface H (u, v)
$|H(u, v)|^2$ = The module square equal to the work of an imaginary on complex conjugate
$S_\eta(u,v)$ = Energy distribution of noise
$S_f(u,v)$ = Energy distribution of the undistorted image
G(u, v) = Fourier transformation of the distorted image

When ranges of noise and the undistorted image (i.e., in this case, images with rounded textures) are unknown and cannot be estimated, the approach consisting in approximation of expression (Eq. 3) by expression is often used:

$$\hat{F}(u,v) = \left(\frac{1}{H(u,v)} \frac{|H(u,v)|^2}{|H(u,v)|^2 + K} \right) G(u,v)$$

where, K is some constant.

Lucie-richardson method: Distinctiveness of a method of Lucie-Richardson consists that it is non-linear that can potentially yield the best result. The second feature a method is iterative that explains difficulties with determination of criterion of a stop of a cycle of an algorithm. The main idea of a method consists in use of an algorithm of maximum likelihood which assumes that the image submits to a law of small numbers. Thus, iteration of an algorithm of Lucie-Richardson can be presented in the form:

$$\hat{f}_{k+1}(x,y) = \hat{f}_k(x,y) \left[h \frac{(-x,-y) * g(x,y)}{h(x,y) * \hat{f}_k(x,y)} \right]$$

Lack of this algorithm is the larger computing complexity increasing with increase in number of iterations. A problem is also selection of the maximal number of iterations for improvement of quality of the image at the acceptable computing expenses.

The filtration according to Tikhonov: For an image reconstruction it is necessary to solve a problem of finding of an extremum (minimum) of some smoothing functional. In the method based on a filtration according to Tikhonov as such functional of C [f] it is possible to use a square of norm of Laplace:

$$C[f] = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} \left(\nabla^2 f(x,y) \right)^2 \quad (4)$$

with padding restriction (communication) of a look:

$$\left\| g - H\hat{f} \right\| = \|\eta\|^2 \quad (5)$$

where $\|w\|^2 \triangleq w^T w$ is Euclidean norm of a vector and $\hat{f}$ is required assessment of the undistorted image. If w-n-component vector, then:

$$w^T w = \sum_{k=1}^{n} w_k^2$$

where, w_k is k vector coordinate. As in our work ourselves wash away the image and external noise at us is absent, $\eta = 0$, therefore, (Eq. 5) it is possible to rewrite as:

$$\left\| g - H\hat{f} \right\| = 0 \quad (6)$$

The solution of an optimizing task (Eq. 4) with a condition (Eq. 6) in the frequencies area is set by expression:

$$\hat{F}(u,v) = \left(\frac{H(u,v)}{|H(u,v)|^2 + \gamma |P(u,v)|^2} \right) G(u,v)$$

where parameter γ (regularization parameter) it has to be chosen so that the condition (Eq. 6) and function was satisfied P(u,v) there is Fourier transformation of function:

$$p(x,y) = \begin{bmatrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

i.e. that function by means of which the operator of Laplace is defined.

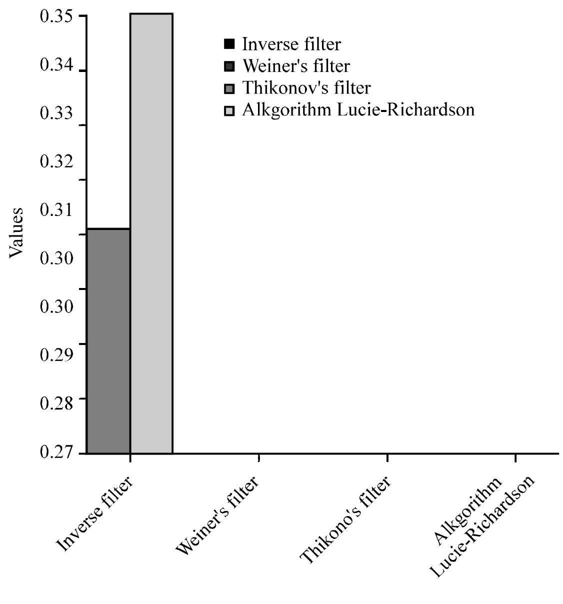

Fig. 1: Comparison of processing mean time of a shot various algorithms of de-blurring

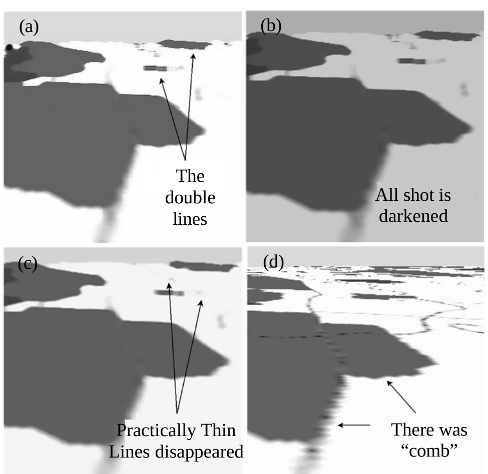

Fig. 2: Restitution the image with the help: a) inverse filter; b) Wiener's filter; c) Tikhono's filter; d) Lucie-Richardson's algorithm

Experiment: Within preparation of the report the experimental comparison of the de-blurring algorithms offered above as a part of the developed algorithm of textures anti-aliasing of the area virtual model was carried out. Comparison of mean time of processing of a shot by various algorithms of de-blurring is given in the Fig. 1. On Fig. 2 images after application of an algorithm of an anti-aliasing are submitted.

Apparently the Fig. 1 algorithm (with use of the inverse filter) showed the best quick action in comparison with the others but algorithms with use of filters by Tikhonov and Wiener do not much more concede to an algorithm with the inverse filter. An algorithm with use of Lucie-Richardson method is the most sluggish. Apparently the Fig. 2 algorithms with use of the inverse filter, Wiener's filter and the Tikhonov filter yield approximately identical result and smooth "comb". But, apparently the Fig. 2b, the Wiener's filter gives the strong blackout and when using the inverse filter on the image there are distortions on a background (there is a padding bordering at contours of objects complicating a problem of their selection on the image; Fig. 2a).

CONCLUSION

By results of the held experiment it is possible to draw a conclusion that the versions of the offered anti-aliasing algorithm using filters of Wiener, Tikhonov and the inverse filter for de-blurring have smaller temporary complexity, in comparison with the version of an algorithm, using a Lucie-Richardison Method. Tikhonov's filter at the same time allows to reach the best attitude of a run time towards quality of an anti-aliasing in comparison with other algorithms of de-blurring. Therefore optimum should recognize the version of the offered anti-aliasing algorithm based on use of the filter of Tikhonov for images de-blurring.

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