COMPARATIVE ANALYSIS OF DEVICES EFFECTIVENESS FOR DETERMINATION OF GEOMETRIC MOMENT SIGNS OF IMAGE

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Possibilities for constructing fast-out special calculator of moment signs with account for a character and, comparative analysis of devices effectiveness are investigated. Mathematical foundation of the design and computer structures on its basis are developed.

INTRODUCTION

The sistem of geometric moment signs is effective one for mathematical description by means of the moments $m_{\alpha\beta}(\alpha,\beta=0,1,2...)$ and the possibility of it's using are well founded in [1].

The objects having dimensions of 32x32 or larger demand large amount of calculations on the computer or microprocessor. This causes considerable material and time losses. Special devices for real - time sign proces - sing were developed.

Let's consider the devices of effective determination of moment signs of image, using the fragment - by - fragment integration method [2] and the multistep accumulations iteration method [3].

1.FRAGMENT-BY-FRAGMENT INTEGRATION METHOD

According to the fragment - by - fragment integration method in the known formula for determination of the moments:

$$m_{\alpha\beta} = \sum_{i=1}^{N-1} \sum_{j=1}^{M-1} B(i,j) i^{\alpha} j^{\beta}, \qquad (1)$$

where

B(i , j) -the function of brightness;

α, β- the order of the moment on the x,y coordinates, accordingly;

N , M - the dimensions of the processing field on the x,y coordinates, accordingly; the calculations should be done in binary expansion, using the following formula :

$$i^{\alpha} j^{\beta} = \sum_{k=0}^{H-1} a_k^{ij\alpha\beta} 2^k, \qquad (2)$$

where

$a_k^{ij\alpha\beta}$ binary expansion ratio correspond to the $m_{\alpha\beta}$ moment and take the values 0 or 1; for every set the set is two dimensional binary mask;H - the number of binary expansion digits

$$H = \max(\alpha)\log_2 N + \max(\beta)\log_2 M, \qquad (3)$$

After necessary transformations we get the following formula for calculation of the moment signs, in which the operation of required digit shifting replaces the multiplication

$$m_{\alpha\beta} = \sum_{k=0}^{H-1} 2^k \Phi_{\kappa}^{\alpha\beta}, \qquad (4)$$

where

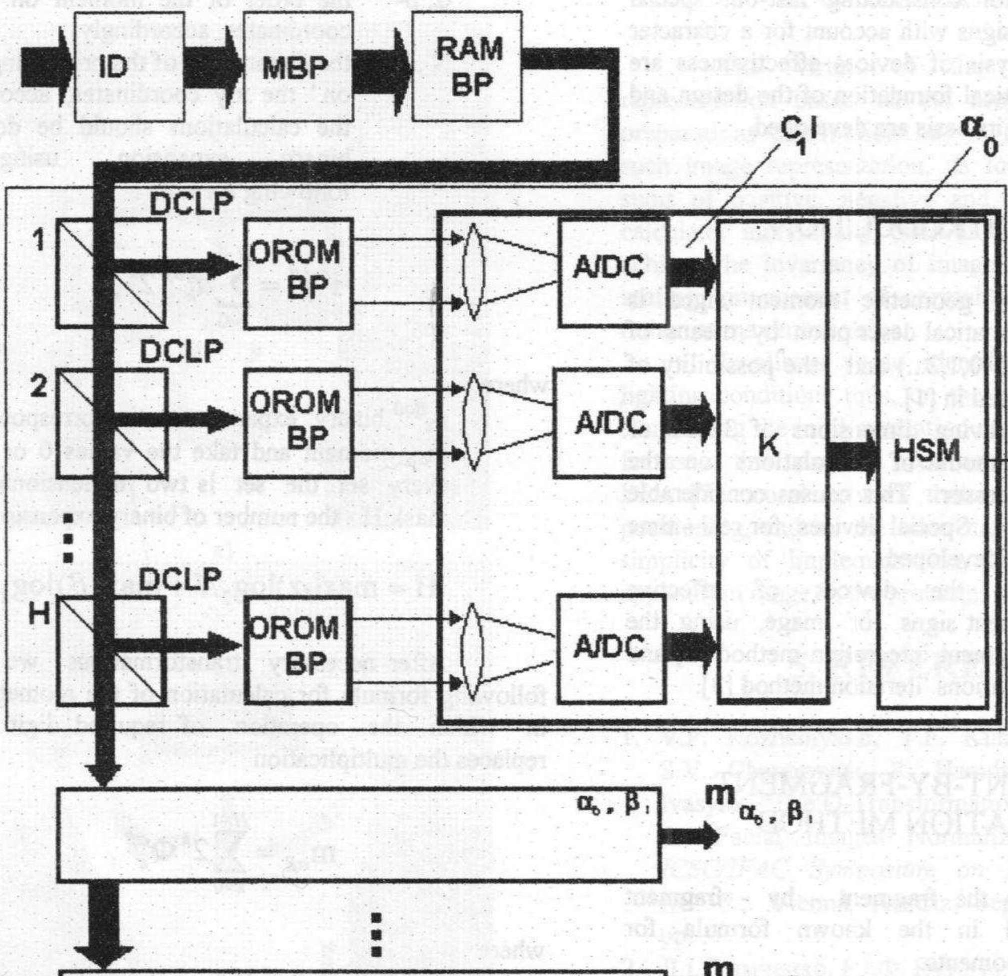
$$\Phi_{\kappa}^{\alpha\beta} = \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} B(i,j) a_k^{ij\alpha\beta}, \qquad (5)$$

is the total image fragment intensity.

According to the fragment - by - fragment integration method the calculation of the moments comes to the following:

- separation of the fragments sequense;
- calculations of the total intensity;
- accumulation of fragment intensities with the corresponding binary weight.

The structural scheme of the parallel version of the device, founded of this method, is shown in Fig.1 and contains besides purely electronic elements (commutators, counter-type adders) input- device (ID) with the parallel optical inlet-outlet, intended for input images of many tones by means of transformation into the set of binary pictures on the analog–to–digital (A/DC PT), the matrix for binary picture storage (MBP), which is picture - type page memory(RAM BP); distributor and connector of light pictures (DCLP), device the performing of which comes to performing of the logical AND operation; space integrator (SI) with the digital output, which may be designed in the form of the focusing lens, photodetector and A/D converter or digital device for calculation.



. Fig.1 The structural scheme of the parallel version of the device, founsded on the fragment-by-fragment integration method

2.MULTISTEP ACCUMULATION INTERATION METHOD.

According to the multistep accumulation iteration method after performing the transformations:

$$m_{\alpha\beta} = \sum_{i=0}^{N-1} \left(\sum_{j=0}^{M-1} a_{i,j} j^{\beta}\right) i^{a} = \sum_{j=0}^{M-1} \left(\sum_{i=0}^{N-1} a_{i,j} i^{\alpha}\right) j^{b}, \quad (6)$$

the formula (1) take the form:

$$m_{\alpha\beta} = \sum_{i=0}^{N-1} m_i^{\beta} i^{\alpha} = \sum_{j=0}^{M-1} m_j^{\alpha} j^{\beta}, \quad (7)$$

where

$\mathrm{m}_{\mathrm{i}}^{\beta}=\sum_{j=0}^{M-1} a_{i,j} j^{\beta}$ the particular moment sign of the i-line;

$\mathrm{m}_{\mathrm{j}}^{\alpha}=\sum_{i=0}^{N-1} a_{i,j} i^{\alpha}$ -the particular mement sign of the j-column.

Thus the moment sign calculation may be reduced to the calculation in the input rate of particular sign in the line (column)

$$\mathrm{m}_{\mathrm{i}}^{\beta}=\sum_{j=0}^{M-1} a_{i,j} j^{\beta}=a_{i,1} 1^{\beta}+a_{i,2} 2^{\beta}+..+ \quad (8)$$
$$+a_{i,m-2}(M-2)^{\beta}+a_{i,m-1}(M-1)^{\beta}, \beta=0,1,2$$

with the following calculation of particular sign in the column (line), which are full moment signs, if the operations on vector - column (vector- line) of the particular line (column) moments are performed:

$$m_{\alpha\beta}=\sum_{i=0}^{N-1} m_{\mathrm{i}}^{\beta} i^{\alpha}=m_{1}^{\beta} 1^{\alpha}+m_{2}^{\beta} 2^{\alpha}+..+ \quad (9)$$
$$+m_{\mathrm{N}-2}^{\beta}(N-2)^{\alpha}+m_{N-1}^{\beta}(N-1)^{\alpha}, \alpha=0,1,2 \ldots$$

From this formula it's clear, that

$$m_{\alpha\beta}(t_{k})=\sum_{i=0}^{k} m_{i}^{\beta} i^{\alpha}=m_{\alpha\beta}(t_{k-1})+m_{k}^{\beta} k^{\alpha}, \quad (10)$$

that is the moment sign of the k-reading is defined as the difference between moment sign, formed during the time $\mathbf{t_k}$ and the time $\mathbf{t_{k+1}}$

$$m_{k}^{\beta} k^{\alpha}=\Delta_{k}^{\alpha}=m_{\alpha\beta}(t_{k})-m_{\alpha\beta}(t_{k-1}), \quad (11)$$

These relations are true both for calculation of full moments and for particular ones (for which $\Delta_l^{\alpha}=a_{il}l^{b}$)

Thus we can calculate the moments successively for the variable field i (or j) and when the polling of the i-line (j-column) is finished we can obtain the moment sign of the i-line (j-column).

It's possible therefore to organize iteration multistep process of accumulation when calculating both particular moment sign and full ones.

The structural scheme of the parallel version, founded on the multistep accumulations method, is shown in Fig.2 and contains the matrix 1 of photoconverters; A/D converter 2; decoders 5,6, coupled in the image input blocks (IIB), counters 3,4; six blocks of particular moment sign accumulations (8-13); each of them calculates particular moment sign from 0 to 4 order.

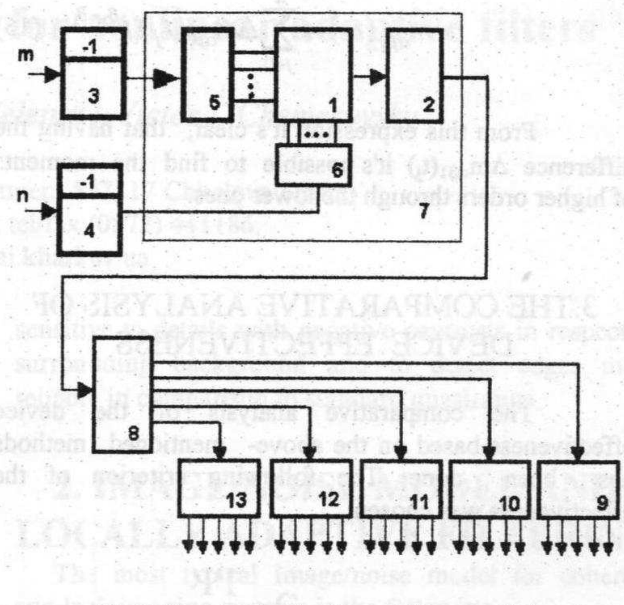


Fig.2. The structural scheme of the parallel version, founded on the multistep accumulations method.

On the basic of the multistep accumulations iteration method we can show the possibility of realization of so important property of the moments as determination of the moments of higher order through the lower ones.

As it was noted formerly:

$$m_{\alpha\beta_{1}}(t_{k})=\sum_{j=0}^{k} m_{j}^{\alpha} j^{\beta_{1}}=m_{\alpha\beta_{1}}(t_{k-1})+m_{k}^{\alpha} k^{\beta_{1}}, \quad (12)$$

For $\beta_1>\beta_2$, with $\beta_1-\beta_2=P$:

$$m_{\alpha\beta_{2}}=\sum_{j=0}^{M-1} m_{j}^{\alpha} j^{\beta_{1}} j^{\cdot\mathrm{P}};$$

$$m_{\alpha\beta_{2}}(t_{k})=\sum_{j=0}^{k}(m_{j}^{\alpha} j^{\beta_{1}}) j^{\mathrm{P}}= \quad (13)$$
$$=m_{\alpha\beta_{1}}(t_{k-1})+(m_{k}^{\alpha} k^{\beta_{1}}) k^{\mathrm{P}}$$

If

$$m_{j}^{\alpha} j^{\beta_{1}}=m_{\alpha\beta_{1}}(t_{j})-m_{\alpha\beta_{1}}(t_{j-1}),$$

then

$$m_{\alpha\beta_{2}}(t_{k})=\sum_{j=0}^{k}(m_{\alpha\beta 1}(t_{j})-m_{\alpha\beta 1}(t_{j-1})) j^{\mathrm{P}}, \quad (14)$$

or

$$m_{\alpha\beta_{1}}(t_{j})-m_{\alpha\beta_{1}}(t_{j-1})=\Delta m_{\alpha\beta_{1}}(t_{j}),$$

then

$$m_{\alpha\beta_2}(t_k)=\sum_{j=0}^{k}\Delta m_{\alpha\beta_1}(t_j)\, j^{\beta_2-\beta_1} \quad (15)$$

From this expression it's clear, that having the difference $\Delta m_{\alpha\beta 1}(t_j)$ it's possible to find the moments of higher orders through the lower ones.

3.THE COMPARATIVE ANALYSIS OF DEVICE EFFECTIVENESS

The comparative analysis of the device effectiveness based on the above- mentioned methods has been done. The following criterion of the effectiveness was chosen

$$Э=\frac{I\Psi}{ЗB}, \quad (16)$$

where

- I - the amount of the input information;
- Ψ- the amount of output information – the number of calculating moments;
- З - equipment expenditure;
- B - image processing time.

The equal servise condition mean that processing of the equal amount of input information takes just the same time when receiving equal numbers of signs (output informations). Under these conditions the efficiency ratio reduces to expenditure ratio

$$K=\frac{Э_1}{Э_2}=\frac{З_1}{З_2}, \quad (17)$$

where

- $Э_1$- efficiency of the device based on the multistep accumulations iteration method;
- $Э_2$- efficiency of the device based on the fragment- by-fragment integration method.

Fig.3 shows the variation of the efficiency ration K with the amount of output information Ψ; the values K_1 and K_2 were determined for 2-gradiation image withe dimensions of 32x32 and 64x64 accordingly; the values K_3 and K_4 were determinatid for 32-gradiation image with the dimensions of 32x32 and 64x64 accordingly.

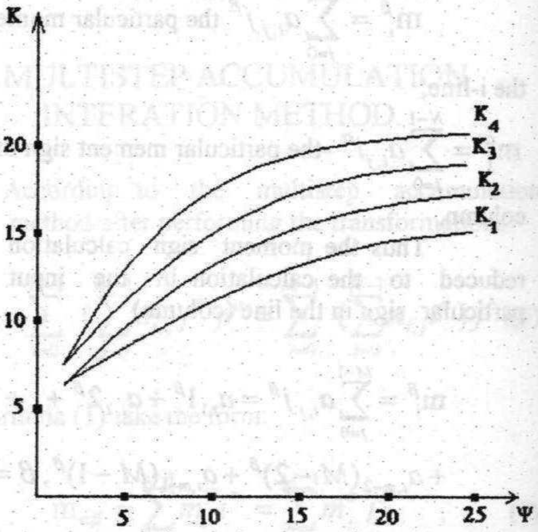


Fig.3 The variation of the efficiency ration K with the amount of output information Ψ

CONCLUSION

The analysis shows that relative effectiveness increases as the image dimensions, the number of it's gradations and the amount of input information increase, as for expenditure they increase less than in the case of number (order) determining moment signs.

The advantages of the devices founded on the multistep accumulations iteration method in comparison with that of the fragment- by-fragment integration method are obvious and are confirmed by the breadboarding.

The breadboards for determination the centre of drafity (the moments) of the image are made, the successive input and processingof the elements of the multigradation image with the frequency to 18 MHz is accomplished.

The devices may be used in X-ray radioscopy and fotometry, while determining different power, light, geometric centres, destribution and separation of their characteristics.

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