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DISTINCTIVE FEATURES OF NUMERICAL COMPUTING APPLICATION BY THE IMPLEMENTATION OF TRACKING AND NORMALIZATION ALGORITHMS

In this paper, we propose the distinctive features of application of numerical computing methods for integral functional by the implementation of normalization and tracking algorithms. The necessity of improvement of known numerical methods is caused by the impossibility to directly apply known numerical methods as they do not allow calculating integrated functionals inside of a tracing frame in real time and in conditions of constant change of its coordinates.

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One of the primary goals, arising from the realization of tracking and normalization algorithms [1], is calculation of the moments of various order on the basis of integral functional like

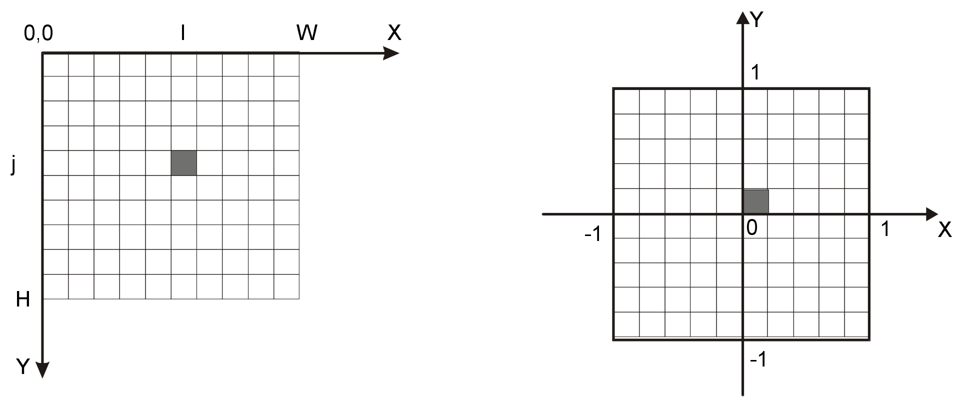
$$\iint_D B(x,y)x^a y^b dxdy ,$$

Where D is an area of a tracing frame.

The trapezoidal method is taken to solve this problem [2]. The given method has been chosen due to its obvious advantages: it is simple to use on the computer, gives precise results by calculation and works with high speed. As alternative the method of rectangles and Gauss method were considered. The analysis of their work on the computer has shown that the method of rectangles is not exact enough; the Gauss method on the contrary gives high accuracy, but works slower.

The function **B(x,y)** is a function of distribution of brightness of the image, set by the table in size **WxH**, i.e. it has the sizes of a tracking framework in pixel. Numeration of pixels in a framework begins from the top left corner, i.e. by calculation of integrals the image will appear in the fourth quarter of the Cartesian coordinate system (fig. 1).

Such arrangement of a system of coordinates is unacceptable, as it will not allow calculating angles of the image rotation. Therefore it is reasonable to place the system of coordinates in the center of the image (fig. 1 b); thus we shall establish constant limits of integration along the axes, equal (-1, 1). It allows calculating integrals irrespective of the sizes of the initial image. Under such conditions the step along axis **X** will equal Δ**x=2/W**, along axis **Y** – Δ**y=2/H, W** - width of the image in process, **H** – its height (the size of a tracing frame)



A) **B)**

Fig. 1 Arrangement of systems of coordinates: a) by receiving values of function B (x, y); b) by calculating integrals

In our case it is necessary to calculate double integrals. Using known formulas of integral evaluation, we shall receive expressions for double integral evaluation. First we replace integral on a variable **x** with its expression through the sum under the formula of trapezoidal method, substituting limits of integration:

$$\int_{-1}^{1}\int_{-1}^{1} B(x,y)x^a y^b dxdy = \int_{-1}^{1} y^b \square \left[\frac{1}{W}\left(B(-1,y)(-1)^a + B(1,y)1^a + 2\sum_{i=1}^{W-1} B\left(-1+\frac{2i}{W},y\right)\left(-1+\frac{2i}{W}\right)^a\right)\right]\square dy$$

Further we write down for this integral its representation the trapezoidal method and after transformations we receive

$$\int_{-1}^{1}\int_{-1}^{1} B(x,y)x^a y^b\,dxdy = \frac{1}{WH}\{(-1)^a(-1)^b B(-1,1) + 1^a(-1)^b B(1,-1) + (-1)^a 1^b B(-1,1) + 1^b 1^a B(1,1)\} + \square$$

$$+\frac{1}{WH}\left\{2\sum_{i=1}^{W-1}(-1)^b B\left(-1+\frac{2i}{W},-1\right)\left(-1+\frac{2i}{W}\right)^a + 2\sum_{i=1}^{W-1}1^b B\left(-1+\frac{2i}{W},1\right)\left(-1+\frac{2i}{W}\right)^a\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}(-1)^a B\left(-1,-1+\frac{2j}{H}\right)\left(-1+\frac{2j}{H}\right)^b + 2\sum_{j=1}^{H-1}1^a B\left(1,-1+\frac{2j}{H}\right)\left(-1+\frac{2j}{H}\right)^b\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{=1}^{-1}\sum_{j=1}^{H-1} B\left(-1+\frac{2i}{W},-1+\frac{2j}{H}\right)\left(-1+\frac{2i}{W}\right)^a\left(-1+\frac{2j}{H}\right)^b\right\}.$$

Parameters **a** and **b** allow writing down the general computing formula: each of them accepts values from 0 to 2, and substituting these values, it is possible to receive computing formulas for the moments of any order. It should be taken into account that while moving the system of coordinates into the center of the image (fig. 1), it is necessary to change coordinates according to which the choice of values of function **B (x, y)** occurs. The coordinates coincide with indexes in the table setting function **B (x, y)**, and point **(i, H–j)** in initial system of coordinates corresponds to the coordinates of the point $\left(-1+\frac{2i}{W},-1+\frac{2j}{H}\right)$ in the central system of coordinates there. Considering these remarks, we shall write down the computing formula of the moments, suitable for computer realization

$$\int_{-1}^{1}\int_{-1}^{1} B(x,y)x^a y^b\,dxdy = \frac{1}{WH}\{(-1)^a(-1)^b B(0,H) + 1^a(-1)^b B(W,H) + \square$$

$$\}(-1)^a 1^b B(0,0) + 1^b 1^a B(W,0) + \frac{1}{WH}\left\{2\sum_{=1}^{-1}(-1)^b B(i,H)\left(-1+\frac{2i}{W}\right)^a + 2\sum_{=1}^{-1}1^b B(i,0)\left(-1+\frac{2i}{W}\right)^a\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}(-1)^a B(0,H-j)\left(-1+\frac{2j}{H}\right)^b + 2\sum_{j=1}^{H-1}1^a B(W,H-j)\left(-1+\frac{2j}{H}\right)^b\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{=1}^{-1}\sum_{j=1}^{H-1} B(i,H-j)\left(-1+\frac{2i}{W}\right)^a\left(-1+\frac{2j}{H}\right)^b\right\}.$$

Further, assigning corresponding values to the parameters a and b, within the limits from 0 to 2, we write down computing formulas for the moments

at a=0, b=0,

$$\mu_{00} = \frac{1}{WH}\left\{B(0,H) + B(W,H) + B(0,0) + B(W,0) + 2\sum_{i=1}^{W-1}B(i,H) + 2\sum_{i=1}^{W-1}B(i,0)\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}B(0,H-j)+2\sum_{j=1}^{H-1}B(W,H-j)+4\sum_{i=1}^{W-1}\sum_{j=1}^{H-1}B(i,H-j)\right\}.$$

at a=0, b=1,

$$\mu_{01}=\frac{1}{WH}\left\{B(0,0)+B(W,0)-B(0,H)-B(W,H)+2\sum_{i=1}^{W-1}(-1)B(i,H)+2\sum_{i=1}^{W-1}B(i,0)\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}B(0,H-j)\left(-1+\frac{2j}{H}\right)+2\sum_{j=1}^{H-1}B(W,H-j)\left(-1+\frac{2j}{H}\right)\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{i=1}^{W-1}\sum_{j=1}^{H-1}B(i,H-j)\left(-1+\frac{2j}{H}\right)\right\}.$$

at a=0, b=2,

$$\mu_{02}=\frac{1}{WH}\left\{B(0,H)+B(W,H)+B(0,0)+B(W,0)+2\sum_{i=1}^{W-1}B(i,H)+2\sum_{i=1}^{W-1}B(i,0)\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}B(0,H-j)\left(-1+\frac{2j}{H}\right)^2+2\sum_{j=1}^{H-1}B(W,H-j)\left(-1+\frac{2j}{H}\right)^2\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{i=1}^{W-1}\sum_{j=1}^{H-1}B(i,H-j)\left(-1+\frac{2j}{H}\right)^2\right\}.$$

at a=1, b=0,

$$\mu_{10}=\frac{1}{WH}\left\{-B(0,H)+B(W,H)-B(0,0)+B(W,0)\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{i=1}^{W-1}\sum_{j=1}^{H-1}B(i,H-j)\left(-1+\frac{2i}{W}\right)\right\}.$$

at a=1, b=1,

$$\mu_{11}=\frac{1}{WH}\left\{B(0,H)-B(W,H)-B(0,0)+B(W,0)+2\sum_{i=1}^{W-1}(-1)B(i,H)\left(-1+\frac{2i}{W}\right)+2\sum_{i=1}^{W-1}B(i,0)\left(-1+\frac{2i}{W}\right)\right\}+$$

$$+\frac{1}{WH}\left\{2\sum_{j=1}^{H-1}(-1)B(0,H-j)\left(-1+\frac{2j}{H}\right)+2\sum_{j=1}^{H-1}B(W,H-j)\left(-1+\frac{2j}{H}\right)\right\}+$$

$$+\frac{1}{WH}\left\{4\sum_{=1}^{-1}\sum_{j=1}^{H-1}B(i,H-j)\left(-1+\frac{2i}{W}\right)\left(-1+\frac{2j}{H}\right)\right\}.$$

By analogy the computing formula for a set of parameters a=2, b=0 can be written down, as well as for other combinations of parameters of a and b. The described formulas are used at realization of algorithms of parallel normalization of images and at tracking of object for defining the changes of displacement, scale, turn sizes [3]. It should be noticed, that calculations in extreme points and along edges of the image cannot be done, as these values bring insignificant contribution in the results of calculations.

Литература:

1. Путятин Е.П., Липанов А.В., Прокопенко Д.О., Теоретические предпо-сылки слежения за протяженными объектами // Системы обработки инфор-мации. Сб. научн.тр., – Харьков.: НАНУ, ПАНИ, ХВУ. – 1998 – С. 80 –84.

2. Бахвалов Н.С. Численные методы.–М.:Наука,1973.– 415с.

3. Путятин Е.П., Липанов А.В. Построение алгоритмов нормализации следящей рамки // Ракетно–космічна техніка: Зб. наук. праць.–Харьков.: ХВУ.– 1999. Вип. I, – С.189–193.