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DETECTOR FOR DEFOCUSED IMAGE EDGE DETECTION

The paper presents the circuit technique realization of the detector for defocused image edge detection, its comparative analysis with the known ones.

Key words: *image edge, detector, image, defocusing, processing.*

Introduction

One of the important tasks of the digital image processing is the edge detection, since edges are the most informatory structural elements of the objects. Today there are many methods for edge detection, realized in software as well as in hardware environments, but their main drawback is that they need much time for processing.

For the improvement of the processing speed there had been created the software and hardware tools, including those on the programming logic integral circuits (PLIC) which are becoming more and more widely used as the element base in the devices for the digital signal processing.

Due to the developed architecture, high timing frequency and low price, PLIC are irreplaceable in simulation and job lot production.

Analysis of latest research and publications

Today the known traditional tools for detecting image edges are the detectors of Roberts, Laplace, Sobel, Prewitt and Kirsh [1-6].

The detectors of Roberts and Sobel [1,3] are very simple to use but do not give the necessary results during the operation with the defocused images.

The contour lines received in such a way, are wide, broad and fuzzy, which disables their recognition by automated systems.

Laplace detector [5] allows to receive 1 pixel width of the line, but its disadvantage is large dimensions of the mask and, as a result - much time for image processing, as well as high sensitivity to noise which complicates the image processing.

The Prewitt's and Kirshes detectors [3,6] are characterized by high level of accuracy in the determination of the edge and resistance to noise, but their disadvantages are difficulties in calculations, much time for image processing and low efficiency during the operation with the broad images.

Contours, detected in the defocused images by the known tools usually suffer from breakthroughs, absence of contour lines or availability of the incorrect ones which do not answer the under research object, but the contour lines are wide, broad and fuzzy, which disables their recognition. Therefore, the issue of the development of tools for detecting the object contours of the defocused images, preserving the high operation speed remains in force.

The objective of the paper is to improve the efficiency in contour detecting of the defocused images by the development of the detector on PLIC.

The main part

The paper presents the circuit technique realization of the detector for defocused image edge detection on the base of cross-point location of two images (the most defocused and the less defocused ones), which are common for the near-border curves and are the contours [3].

Since the near-border curves are fuzzy and oblong, they may be received in the periphery of the edgecard using the linear interpolation. The location of the cross-point shall then be determined by the system of the equations [5]:

$$\begin{cases} \dfrac{U(m+L,n)-U(m,n)}{U(m+1,n)-U(m+L,n)} = \dfrac{\delta}{d-\delta}; \\ \dfrac{U(m+L,n)-U'(m,n)}{U'(m+1,n)-U(m+L,n)} = \dfrac{\delta}{d-\delta}, \end{cases}, \qquad (1)$$

where d – distance between the pixel centers, δ – subpixel shift, *U(m,n), U'(m,n), U(m+1,n), U'(m+1,n)* – intensities of the *N-th* and the *N+1-th* pixel before and after the sharpness of the picture.

The subpixel shift shall be determined as[7]:

$$\delta = \frac{U(m,n)-U'(m,n)}{U'(m+1,n)-U(m+1,n)} \cdot d. \qquad (2)$$

Detector for defocused image edge detection (fig.1) is composed of the following blocks:

Input and output interfaces ensure the transformation of the image input data and the output image;

column diagram analysis block for each image w3ith the purpose of receiving the factors, which determine the degree of image defocusing;

block for factors' comparison;

diminution block (this block carries out the pixel-by-pixel diminution of two images: (the most defocused and the less defocused ones);

block for analysis of the sign, received in the result of images diminution, the change of which illustrates the availability of the contour.

Detector for defocused image edge detection operates as follows: the input interface 1 receives the package of pixel data for the processing of the determined length, which compose the half of the shot. The data enter the corresponding inputs of the column diagram analysis blocks 21, 22,…, 2N, on the output of which we receive the calculated values of the factors, which allow to determine the degree of the image defocusing.

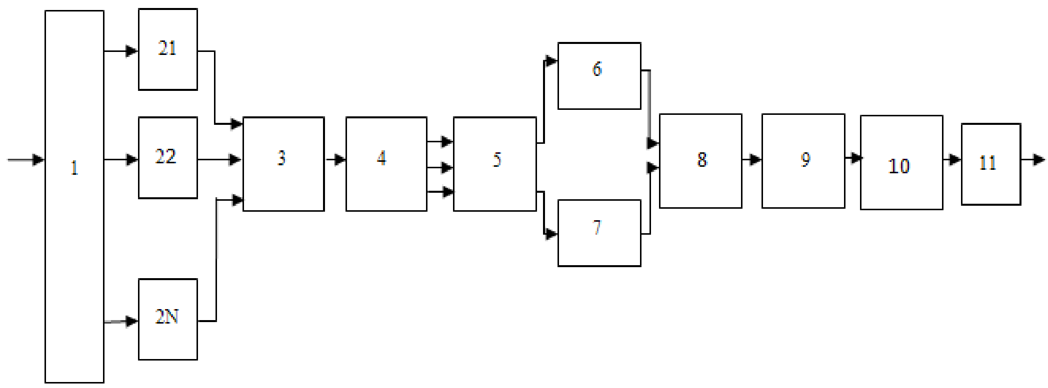


Fig. 1. Structural diagram of the detector for defocused image edge detection (1 – input interface; 21, 22,…, 2N – column diagram analysis blocks; 3 – multiplexr; 4 – register; 5 – comparison block; 6 – register for saving the conditionally clear image; 7 – register for saving the conditionally fuzzy image; 8 subtraction circuit; 9 – analysis block; 10 – register for saving the output image; 11 – input interface)

The values of the factors through the multiplexer 3 enter and are stored in the register 4. The block of comparison compares the values of the factors which allow to select the most defocused and the less defocused images. Diminution block 8 carries out the pixel-by-pixel diminution of the received images which were stored in the registers 6 and 7. The calculated results enter the analysis block which analyzes the sign by image diminution, the change of which demonstrates the availability of the contour. From the analysis block 9 the data enter the register 10, where they are being saved and then put out by the output interface 11. The result of the image processing is a drawn selected contour, which preserves the contours of the small details.

Let us describe in details the operation of the histogram block analysis from the above structural diagram (fig.1).

The diagram receives the image in the kind of matrix of pixels with definite values of intensity. The image, stored in the memory device is supplied pixel-by-pixel to the input interface. From the memory block the value of the pixel intensity is supplied to the comparators which determine the maximum $I_{\max}$ and that close to the maximum $I_{\max-1}$ image intensity value, which enter the diminution block to receive ΔI. The next step is the diminution from the received difference ΔI the value of intensity in point (*i, j*) of the image. Then the received values shall be divided by the matrix order of the image with further determination of the sum total which equals the value of the factor which characterizes the degree of image defocusing.

The suggested histogram block analysis operates according to the formula :

$$k_h = \sum_{i=1}^{n}\sum_{j=1}^{m} \frac{(I_{\max} - I_{\max-1}) - I_{i,j}}{n} \text{ on condition that } n = m, \tag{3}$$

where $I_{\max}$ – maximum value of intensity; $I_{i,j}$ – value of intensity in the point (*i, j*); n, m – matrix order of the image; *h* – number of images being compared.

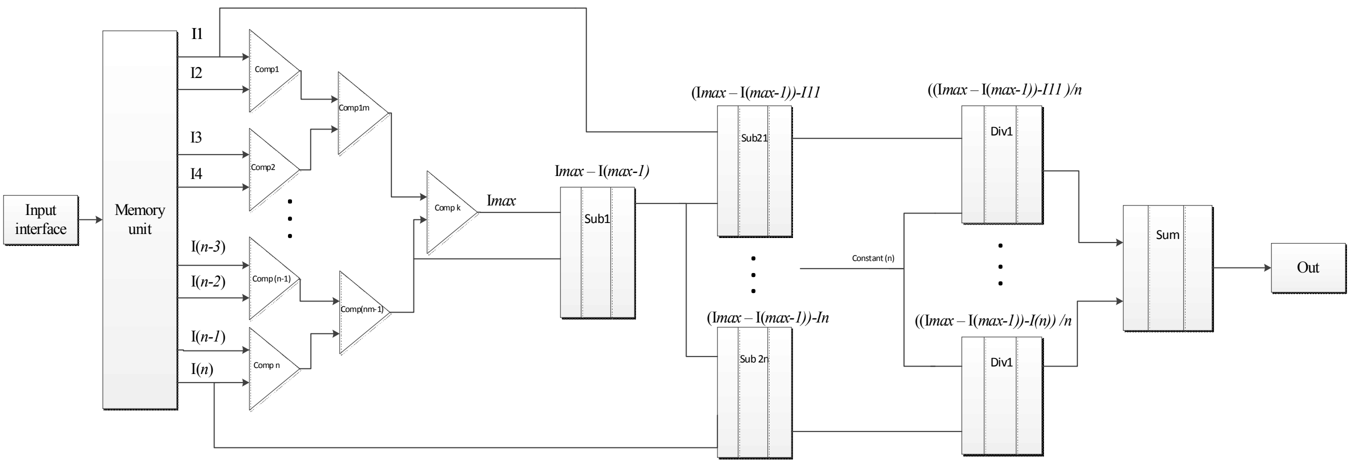
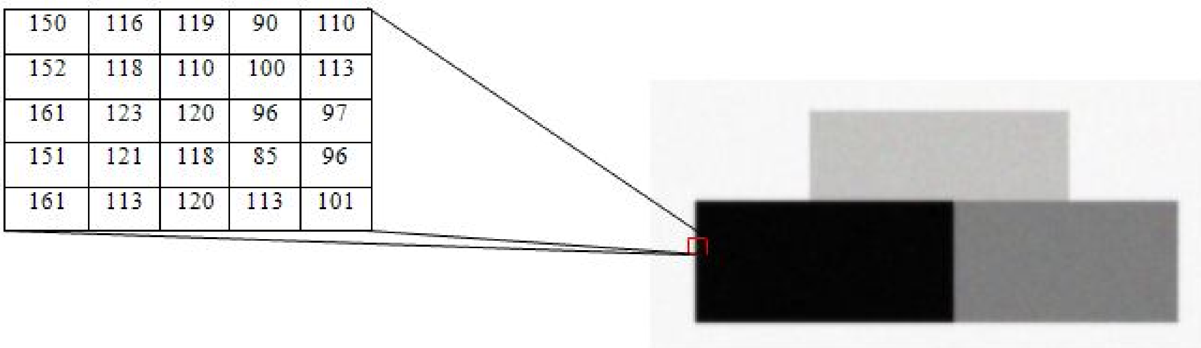


Fig. 2. Structural diagram of histogram block analysis on PLIC

The number of registers, comparators and blocks of arithmetic operations must respond to the image length.

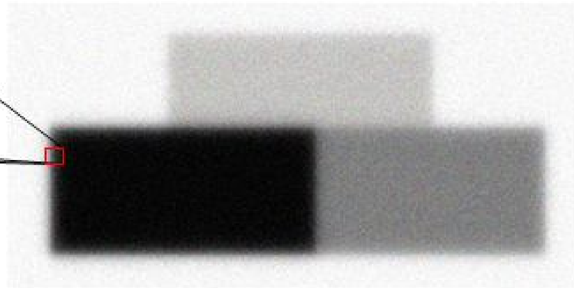
To prove the operation accuracy of the detector for defocused image edge detection we carry out the simulation in CAD Quartus II 9.0. Test images are the defocused images (fig. 3 a and 3).



150	116	119	90	110
152	118	110	100	113
161	123	120	96	97
151	121	118	85	96
161	113	120	113	101

a)

149	114	129	89	108
147	110	111	95	101
151	121	134	87	96
134	113	119	83	93
143	111	131	108	97



b)

Fig. 3. Values of intensity of pixel massive of the defocused images (a – the less defocused image, б – the most defocused image)

As a result of the operation of the detector for defocused image edge detection we receive: (please see fig.4).

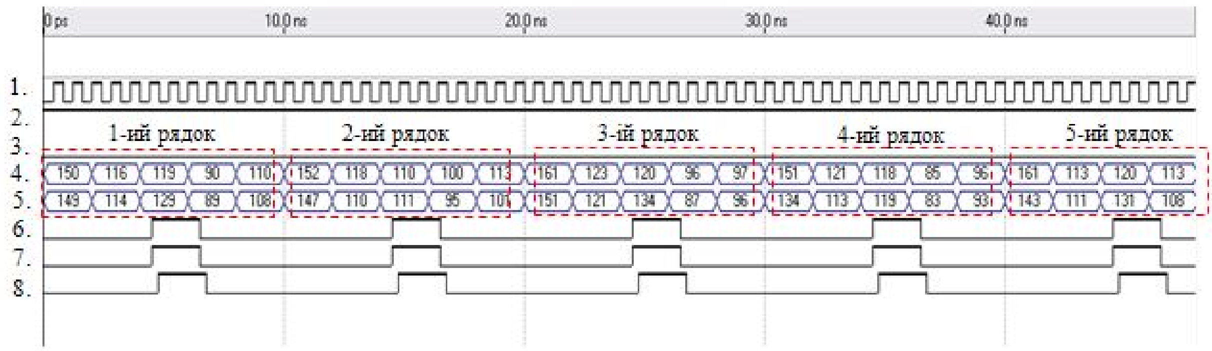


Fig. 4. Simulation results in Quartus II 9.0 (1 – timing frequency; 2 – enabling signal; 3 – reset signal; 4 – output of the intensity values of the first image; 5 – output of the intensity values of the second image; 6 – diminution result; 7 – recording diminution result in the register; 8 – reading the diminution result from the register)

To verify the accuracy of the detector's operation we compare the obtained result of the simulation with the result of image processing in Matlab 7 (Fig. 5).

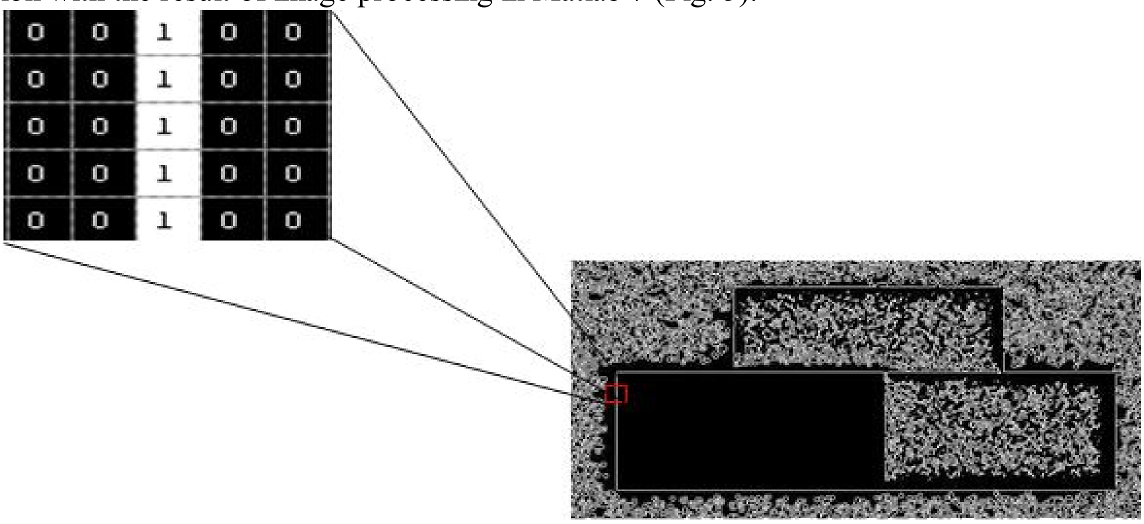


Fig. 5. Values of intensity of pixel massive of the image with the selected contours

To prove the operation efficiency of the detector for defocused image edge detection, there had been conducted the comparative analysis with the traditional detectors for image edge detection.

The comparative analysis uses the evaluation of the image quality. This image is characterized by a number of metrics, which show the accuracy the received image is saved with the original. One of the most famous metrics is the mean-square deviation (MSD) and Peak Signal to Noise Ratio (PSNR). It should be noted that the less the value of the mean-square deviation, the more the received image is stored with the original one, and the more the and Peak Signal to Noise Ratio – the sharper is the image

The comparative analysis of the detector operation as for the evaluation of the quality of the received image is presented in table 1.

Table 1

Comparative analysis

Detectors / Criteria	Detector of Roberts'		Detector of Laplace		The Sobel Edge Detector		Detector of Previtt		Detector of Kirsch		The suggested detector	
	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%	25%	50%
mean-square deviation	3508,1435	3954,4385	11239,0119	16574,2561	11159,8192	15163,9873	7297,5615	9265,0515	34163,0571	37239,9889	103,958	2237,7256
Peak Signal to Noise Ratio	12,68	10,16	7,6235	5,9365	7,6542	6,3227	9,499	8,4207	2,7952	2,4207	42,1561	14,6327

The data from the table allow to conclude that the results, received from the suggested detector are more accurate since the peak signal to noise ratio has the biggest value which testifies the less noise of the image, and the mean-square deviation value is low which testifies the accuracy of the received contours (shows the degree of defocusing).

Conclusions

There had been suggested the circuit realization of the detector for defocused image edge detection on the base of the location of cross points of the two images (the most defocused and the less defocused), which are common for the boundary curves and which are contour ones. For the comparison of this detector with the traditional ones there had been used the following criteria: peak signal to noise ratio (PSNR) and a mean-square deviation (MSD). In the result there had been received the following values PSNR=42.1561, and MSD=103.958, which are one order higher then the traditional ones. The result of the research allows to make a conclusion that the detector allows to improve the accuracy and to decrease a width of the contour line.

Since the detector is built on PLIC, it improves its operation speed in comparison with the operation in the software environment and the operation of the traditional detectors.

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