THE COMPARATIVE ANALYSIS OF THE OPERATORS USED FOR EDGE DETECTION OF THE IMAGE FOR THE ADJUSTMENT OF SHARPNESS

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Abstract

The visual perception of subjects is appreciably defined by sharpness of their borders (edges). The image having fine color balance, but not having a clear boundary between color areas, can be perceived as unsatisfactory on quality. Therefore sharpness adjustment is an important stage of image processing. Adjustment can be carried out by various modes. Before decision-making on a choice of the strategy of adjustment of sharpness it is necessary to carry the image to one of the groups from the point of view of semantics. It can be made on the basis of the analysis of the egdes. For this reason special attention should be given reliability of these procedures. Now for the decision of this problem there is a set of program operators, such as Canni-operator, LoG-operator, Sobel-operator, Prewitt-operator and Roberts-operator. These operators use various algorithms of allocation of important borders on the image. The main goal of this experiment was the comparative analysis of different operators and revealing of most effective of them. The special attention was given also to the analysis of histograms of received images (quantity of pixels which concern edges). It gives some recommendations of practical importance. It has allowed to choose most effective of operators, which can be used further for the purpose of the adjustmens of sharpness.

Key words: *Sharpness, Image quality, Edge detection, Operators for edge detection, Semantics of the images, Comparative analysis, Histograms.*

Introduction

The visual perception of subjects is appreciably defined by sharpness of their borders. The image with fine color balance, but without a clear boundary between color areas, can be perceived as unsatisfactory on quality. Therefore sharpness adjustment is an important stage of processing of images. Before decision-making on a choice of the strategy of adjustment of sharpness it is necessary to carry the image to one of groups from the point of view of semantics. It can be made on the basis of the analysis of the egdes.

Operations of edge detection are carried out at the first analysis stages of images, and their quality performance is very important for speed, accuracy, and sometimes possibility of the further analysis. For this reason special attention should be given reliability of these procedures. Nowadays for the decision of this problem there is a set of the software, one of which is program MATLAB. In this program there is a possibility to use of various operators for allocation of contours. The most important from them are the following:

1. **Canni edge detector,** which principle can be described as follows:

1) the image smoothes out by the Gauss-filter for noise reduction,

2) in each point the gradient is calculated $g(x,y) = \left[G_x^2 + G_y^2\right]^{1/2}$ and also edge-direction: $\alpha(x,y) = \operatorname{arctg}(G_y/G_x)$ Difference points are defined as a points of a local maximum of a gradient,

3) Difference points cause growth of crests on the image of the module of a gradient. Then the algorithm traces top of these crests and appropriates zero value to points which locations is not on a crest. Further crest pixels are exposed to threshold processing with the use of two thresholds T1 and T2, and TI < T2. The crest pixels, which value is more T2, are called as strong, and the pixels which values get to an interval [T1,T2], are called as weak,

4) The algorithm makes connection, adding to strong pixels the weak.

2. **LoG edge detector.** The function of Gauss:

$$h(r) = -e^{-\frac{r^2}{2\sigma^2}},$$

$r^2 = x^2 + y^2$, σ is the standard deviation.

The Laplassian of the Gauss-function is defined as

$$\nabla^2 h(r) = -\left[\frac{r^2 - \sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}}.$$

Also it is accepted to name this function LoG. The taking of the second derivative is the linear operation, therefore image convolutionion with $\nabla^2 h(r)$ is the same that image convolution with smoothing function and then application of the operator of Laplace. In these actions key properties of the LoG edge detector are shown. Image convolution with $\nabla^2 h(r)$ gives two effects: it smooths the image (reduces noise) and calculates a Laplacian that reveals edges on the image. Final localization of edges consists in finding of intersections of zero level between double edges.

3. Sobel edge detector. This operator for detection of overfalls uses special masks shown in Fig. 1b [1] for numerical approach of derivatives *Gx* и *Gy.* The gradient in a central point of a neighborhood is calculated under the formula

$$g = [G_x^2 + G_y^2]^{1/2} =$$
$$= \left\{[(z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)]^2 + \right.$$
$$\left. + [(z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)]^2\right\}^{1/2}$$

Edge detection by Sobel operator in program MATLAB is implemented by the function **edge** [2].

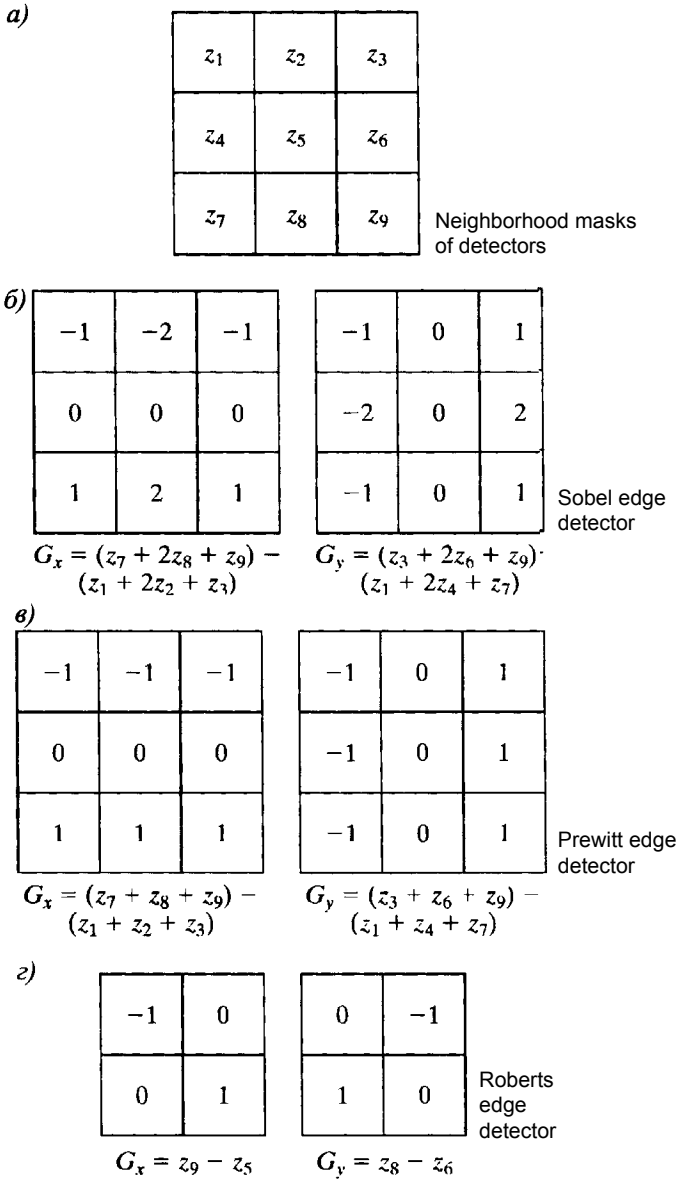

Fig.1 Different edge detectors [1]

4. Prewitt edge detector [3] uses a mask as shown in Fig. 1c**.** Prewitt edge detector is easier to implement from the computing point of view, however thus there can be errors of calculations (it is possible to show, that coefficients 2 in masks provide certain smoothing of result).

5. Roberts edge detector uses special masks for numerical approach of derivatives *Gx* and *Gy* as shown in Fig. 1d. It is one of the oldest detectors used at digital image processing, and from Fig. 1d it is visible that it is arranged easier others. This operator is used in many programms, where simplicity and speed are defining factors of processing.

Experimental

The main goal of this experiment was the comparative analysis of described operators and definiton of most effective of them. The special attention was given also to the analysis of histograms of received images (what amount of pixels from all array are detected by the operator as the edge).

Results and Discussion

The comparative speed-analysis of the operators (Tab.1) has shown that the greatest temporal expenses are demanded by handling by means of Canni edge detector, that can be connected to complexity of algorithm. The fastest and most effective among the presented filters is Roberts's operator.

Table 1.
The comparative speed-analysis of the different edge detectors

Operator	**Time of processing, s**
Canni	33,9
LoG	23,4
Prewitt	23,2
Sobel	23,1
Roberts	23

As an example of influence of the operators on real images we will consider the image in Fig. 2a. It is possible to note, that on the picture there are areas which are not in focus (in particular, the left upper part). They can be carried to the areas which are not important for the future adjustment of sharpness. It's very important, that by the operator have been selected

only important boundaries in the image (such as flower and stalk circuits). Comparing results of action of various filters, it is possible to note that Canni edge detector, which is declared by some authors [1] as the most powerful among all operators used in program MATLAB, selects not only important boundaries of image elements, but also elements which aren't important from the semantic point of view, and it is extremely undesirable. It's clearly on histograms, that in comparison with other operators Canni detector has selected a much bigger part of the information as the edges. Noise suppression usage in Canni algorithm [4] increases computing expenses and leads to distortion and even loss of particulars of boundaries that negatively affects the results.

LoG edge detector has shown more good results, however in this case undesirable elements also have been partially selected.

Other operators (Sobel, Prewitt and Roberts) have consulted with the task approximately equally (as shown in Figures and histogramms), however Roberts's operator has certain advantage from the point of view of definition of selected boundaries and speed performance.

The experimental data representing the changes are given on Figures 2b-f.

Canni , megapix	**LoG, megapix**	**Sobel, megapix**	**Prewitt, megapix**	**Roberts, megapix**
0,22	0,1	0,06	0,06	0,06

Fig. 2a. Edge-pixels

Fig. 2b. Canni edge detector

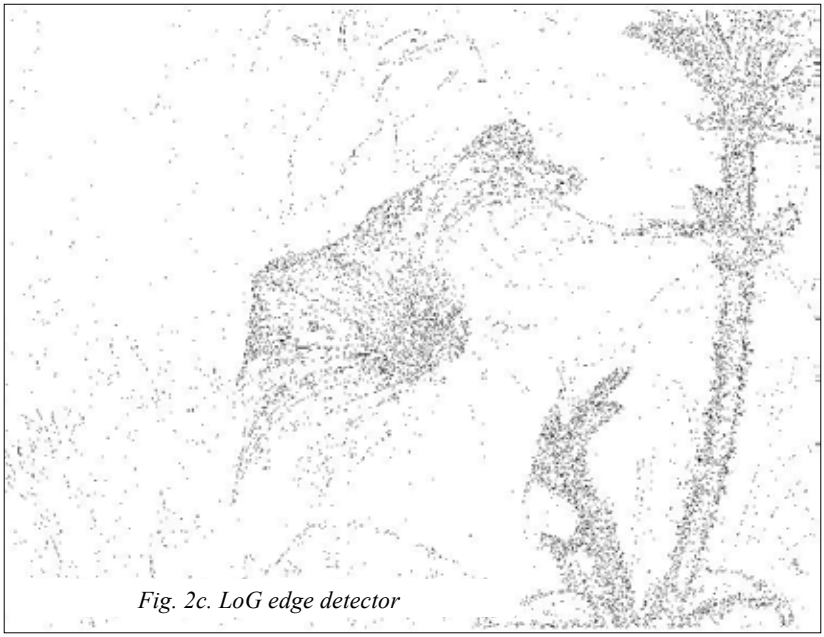

Fig. 2c. LoG edge detector

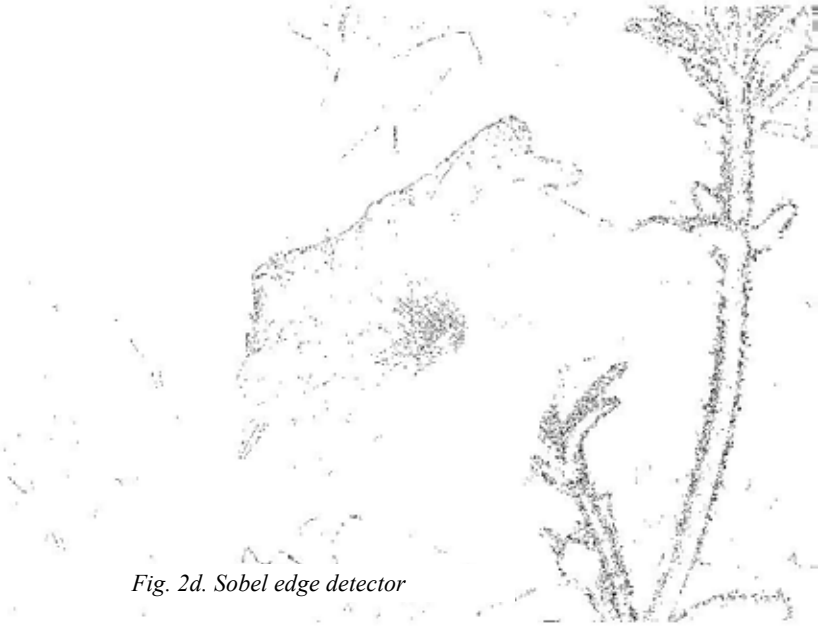

Fig. 2d. Sobel edge detector

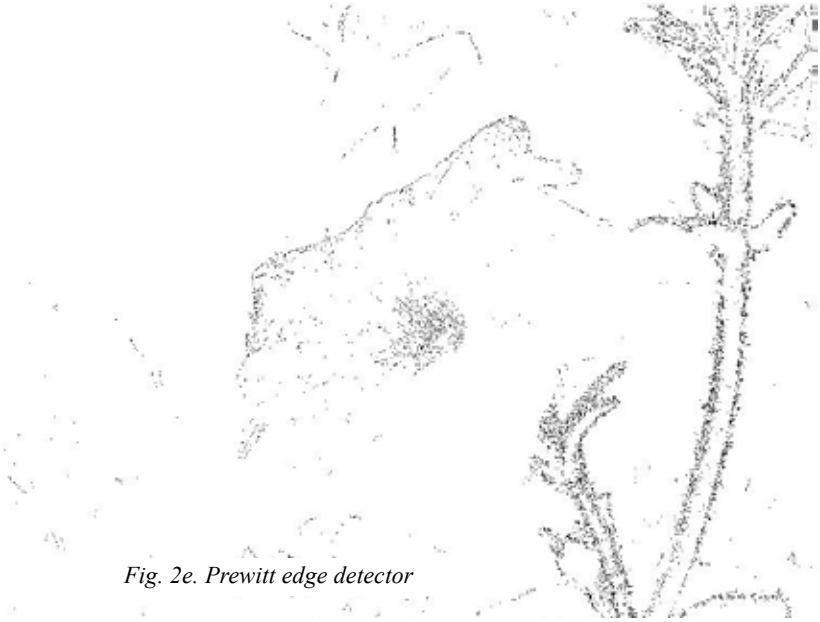

Fig. 2e. Prewitt edge detector

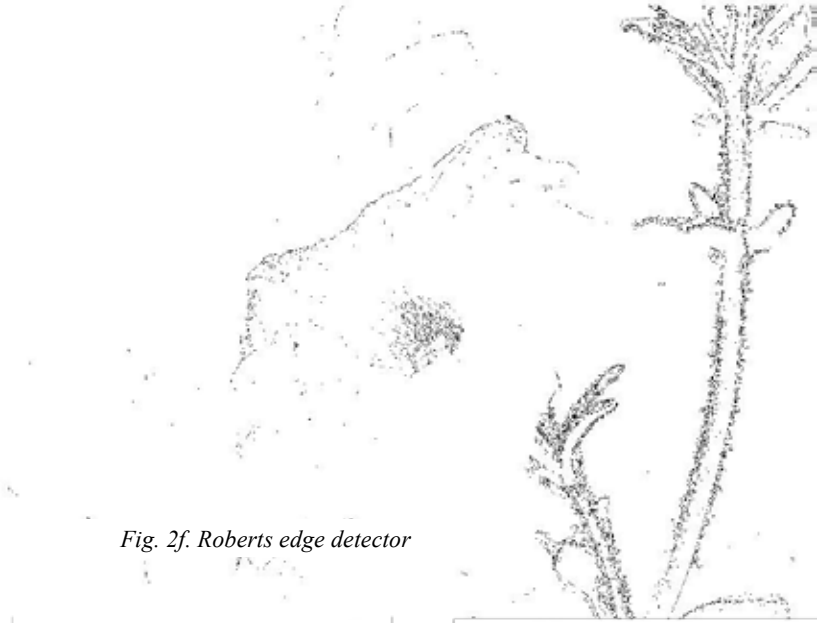

Fig. 2f. Roberts edge detector

T = 60

T = 80

T = 100

T = 120

Fig. 3

For the purpose of the further adjustment of sharpness it's also important to choose the suitable threshold – it's the possibility to select only the significant edges of images and do not select the noises. The results of the edge selection with the different thresholds (T) are given on Figure 3.

Conclusions:

1. The comparative analysis of different edge detectors, which usage is important at determination of the edges in images for the purpose of the further adjustment of sharpness, is carried out.
2. The best results are reached with usage of Roberts operator – from the point of view of speed and from the point of view of selection of important edges of subjects.
3. Roberts edge detector can be recommended for the task decision to classification of graphic originals by semantic signs for the purpose of the further development of recommendations about sharpness adjustments.

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