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ESTIMATION OF QUALITY METHODS DISGUISE IMAGES FOR DETECTION EDGE CONTOURS

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The main types of errors introduced by methods of masking (disguise), measures assessing the quality of masking. Showing approaches to comparative evaluation of methods of masking. Considered presents practical methods for quantifying the quality of the detection and localization of the contours in images. It was concluded that to justify the selection of one of the existing methods to mask the comparative quantitative measure of quality masking images using GT-images

Keywords: image of masking (disguise), GT-image, method of assessment, measure estimates, quality of detection, quality of the localization.

У статті визначено основні види помилок, що вносяться методами маскування, а також заходи оцінки якості маскування. Показані підходи до порівняльної оцінки методів маскування. Представлені практичні методи кількісної оцінки якості виявлення і локалізації контурів в зображеннях. Як висновок можна сказати, що для обґрунтування вибору одного з існуючих методів маскування, використовується порівняльний кількісний показник якості зображення маскування з використанням GT-зображень

Ключові слова: образ маскування, GT-зображення, метод оцінки, міра оцінки, якість виявлення, якість локалізації.

Introduction

Image processing is being used in almost all areas of human activity. Increase the levels of information to be processed at the same time the requirement to reduce the time spent on processing. The technology of digital image processing requires to the development of new methods of filtering, pattern recognition, data compression and image interpretation. Data on the geometric characteristics of objects in the image borders — contours are the most informative for the largest part image processing systems.

The most of methods to search for contours use and continuously improved for specific tasks of image processing. The fact of continuous improvement, new methods of finding the contours of dissatisfaction researchers showed the quality and reliability of existing ones. Consequently, task the quality estimation methods to detect contours of objects in realistic images is the actual problem to justify the use of a particular method.

The idea of this article is analyze of practical estimation the quality of methods of image disguising techniques (quality of detection and localization of edge) for the detection contours in images.

By disguise the images we mean methods and algorithms detection (search and localization) contours (contours borders) in images by using a sliding mask (filter). Usually, the mask is a kind of a square matrix equivalent to a specified group of pixels in the original image, the elements of which are called coefficients.

Quality estimation methods of masking can be divided into theoretical and empirical [1–6]. It depends on whether they use a theoretical analysis or review of the experimental results of a method and algorithm.

As is well known the use of theoretical methods to assess disguising [1–6], the input of the method (algorithm) are described mathematically, and its performance is determined analytically or by simulation. The main disadvantage of these methods is a simplified mathematical model describing the input signal and noise, as well as the difficulty of applying the method to the borders of modern detectors because of the complexity of algorithms of the latter.

Methods of empirical estimates typically measured either allocated shape borders or probability of a correct definition of the boundary pixel by studying the brightness of pixels in its neighborhood. Empirical methods are divided: a method used estimate ground truth (GT-images — images that contain a common understanding of the researcher's border) and the so-called empirical estimate of purity (empirical goodness methods), that this estimate does not apply. This group of methods and include those in which the performance of different methods evaluate people.

A major shortcoming of the known empirical methods in their practical application is the fact that they can not measure the displacement of the boundary pixels allocated about their true position and do not solve the problem of choosing the optimal method of disguising (detection edge) for the specific task of image processing.

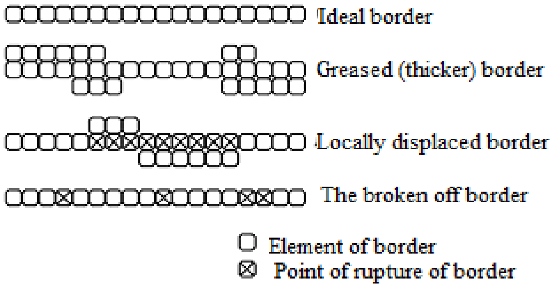
Most methods of estimate use the results of the study of algorithms for test images with GT-images. Measures differences (discrepancy measures) are played the main role for count estimates the results. Currently, more often used images, simulating complex to highlight the boundaries between [1; 4; 11] associated with the presence of the boundary changing contrast (for example, well-known test images — band disappears, a snail, a decaying part).

1. The main types of errors, imported by methods of masking (disguise)

The main criterion of efficiency methods of masking are the maximization percent of correctly selected boundary pixels (detection high level) and a high level of localization (determination of proximity of the selected circuits to appropriate to them on the GT-image).

By this time it was not possible to create a measure equally effectively estimating these two characteristics. It is connected with uncertainty principle between high level of detection and a high level of localization. Accordingly, for an estimation of the given characteristics different measures of distinctions are proposed.

To the main types of errors (see figure), imported by masking methods in required contours of objects of the image, it is possible to carry: contours smearing, local and global offsets, ruptures of contours.



The main types of errors,
imported by methods of masking

Efficiency methods of search and localization of contours in practice can be estimated proceeding from following results of processing [1–12]:

– precision of determination of points of a contours;

– uniqueness of each boundary (for each boundary of object there should have only one edge detection contours);

– stability of the method to noise;

– simplicity of hardware implementation;

– speed of the finding contours and necessary computational rate for processing;

– the thickness of the boundary allocated (to strive for one point (line));

– off set of bias circuit (edge).

2. Measures distinctions for methods of masking (disguise)

Analyze measures of distinctions of methods of masking can be divided into 2 groups of measures conditionally: estimations of quality of detection and estimations of localization.

2.1. Main measures estimation the quality methods of masking

Following main measures of an estimation of quality of detection [1–6] are known.

The error of first kinds determined as attitude of the wrong distinguished border pixels toward the incurrence of pixels being not a border:

$$\alpha(A,B)=\frac{n(B\setminus A)}{n(X\setminus A)}, \qquad (1)$$

where n(.\.) is a number of pixels in a corresponding image (great number).

The error of second kinds is determined as attitude of the undistinguished border pixels toward the incurrence of border pixels:

$$\beta(A,B)=\frac{n(A\setminus B)}{n(A)}. \qquad (2)$$

Sensitiveness is attitude of the correctly distinguish border pixels toward the incurrence of border pixels of character GT-image:

$$Se=\frac{n(B\cap A)}{n(A)}=1-\beta. \qquad (3)$$

Specificity is attitude of the distinguished not border pixels toward the incurrence of not border pixels of character GT:

$$Sp=\frac{n(X\,/\,B\cup A)}{n(X\,/\,A)}=1-\alpha. \qquad (4)$$

2.2. Specified measures estimation quality for methods of masking grayscale images

It is possible to carry to measures of an estimation of quality of detection and Euclidean mean squared measure (metrics) which is applied at comparing of two halftone images [2–8]:

$$\| f-g\|=\left[\frac{1}{N}\sum_{x\in f}(f(x)-g(x)^2)\right]^{1/2}, \qquad (5)$$

where $f(x)$, $g(x)$ — value of image brightness $f(g)$ in a point x.

The considered measures of an estimation of quality of masking have the big practical application, their lacks [2–8; 11–13] thus were repeatedly marked. T he most diadvantage is distinctions between images f and g are defined on total number of discrepancies in between regardless to an image which represents these images.

So, small shift in the estimated image concerning the GT-image, affecting a great number of pixels, but not changing the form of an image, leads to the low values of an estimation of quality of masking that not is admissible at an estimation of quality of localization of circuits. The small distortions affecting insignificant number of pixels, but essentially changing the form of represented object, give high values of the given measures. The specified disadvantages necessary are taken into consideration at practical estimation methods of masking (detectors of boundaries) by means of these measures.

2.3. Measures estimation localization for methods of masking

Criterion of an averaged square error can serve of measure estimation localization of contours in masking methods (which defines precision of determination of contours objects in images) — in aggregate with criterion of a minimum of distance between an ideal (pattern) image and the contours received as a result of their detection (localization) [2–4].

In this connection, as a result of detection (localization) of circuits frequently there are errors of two types:

– on the image the point is marked as contour, and on an ideal image it does not concern a contour;

– on the processed image the point is not marked as contour, but it is that on an ideal image.

It is possible to carry an average error of distance to practical measures of an estimation of localization [2; 3; 6–8]:

$$e(A,B)=\frac{1}{n(B)}\sum_{x\in B} d(X,A), \qquad (6)$$

where $d(X, A) = \inf r(x, a)$ in a considered discrete situation also represents the metrics of the shortest way [2; 6; 13].

To practical measures of an estimation of localization it is possible to refer an average error of distance [2; 5; 6]:

$$e^2(A,B)=\frac{1}{n(B)}\sum_{x\in B} d(X,A)^2. \qquad (7)$$

Recently, at an estimation of quality of methods of selection of circuits as a measure of an estimation of localization use the criterion showing a level of likeness processed and ideal images (FOM) [6; 11; 13].

Criterion FOM (Figure of Merit) corresponds to empirical distance between the ideal images presented in the form of circuits f and circuits, received as a result of handling g:

$$FOM(f,g)= \\ =\frac{1}{\max\{card(f),card(g)\}}\sum_{i=1}^{card(g)}\frac{1}{1+d^2(i)}, \qquad (8)$$

where $card\ (f)$ — an amount of pixels in the image f; $card(g)$ — an amount of pixels in the image g; $d(i)$ — distance between i-th pixel f and the nearest to it in pixel of century g.

In practice also use the metrics of Prieto [9; 11].

Lack of the enumerated measures of an estimation of localization is that they are frequently insensitive to beta errors. A lack of criterion FOM and Pratt's metrics [6; 9; 11; 13] — high values on the images containing sections of ruptures of boundaries (holes) and sections where the turned out boundary circuit oscillates round the true position.

At an estimation of quality of methods of selection of circuits as a measure of an estimation of quality of detection it is offered to use the criterion showing a level of their difference (RMS).

Criterion RMS (root mean squared error) represents an averaged square error defined by expression [2; 3; 13]:

$$RMS(f,g)=\left[\frac{1}{card(X)}\sum_{x\in X} f(x)-g(x)^{\ 2}\right]^{\frac{1}{2}}, \qquad (9)$$

where $f(x)$, $g(x)$ — intensity of pixels x in f_i and g_i; X — set of pixels on the processed image.

At comparing of methods it is necessary to result average estimations of criteria FOM and RMS, received for the given amount of images.

For an estimation of quality of localization in halftone images also use a measure of structural similarity SSIM or its modifications (3SSIM, MS SSIM) [12].

Value of a measure of a structural similarity is defined by expression:

$$\mathrm{SSIM}=\left(\frac{\sigma_{XY}}{\sigma_X\sigma_Y}\right)\left(\frac{2\overline{XY}}{(\overline{X}^2)+(\overline{Y}^2)}\right)\left(\frac{2\sigma_X\sigma_Y}{\sigma^2_X+\sigma^2_Y}\right), \qquad (10)$$

$$\overline{X}=\frac{1}{M\,N}\sum_{i=1}^{M}\sum_{j=1}^{N}x_{ij},\ \overline{Y}=\frac{1}{M\,N}\sum_{i=1}^{M}\sum_{j=1}^{N}y_{ij}, \qquad (11)$$

$$\sigma^2{}_x=\frac{1}{(M-1)(N-1)}\sum_{i=1}^{M}\sum_{j=1}^{N}(x_{ij}-\overline{X})^2, \qquad (12)$$

$$\sigma^2{}_Y=\frac{1}{(M-1)(N-1)}\sum_{i=1}^{M}\sum_{j=1}^{N}(y_{ij}-\overline{Y})^2, \qquad (13)$$

$$\sigma_{XY}=\frac{1}{(M-1)(N-1)}\sum_{i=1}^{M}\sum_{j=1}^{N}(x_{ij}-\overline{X})(y_{ij}-\overline{Y}), \qquad (14)$$

where SSIM — value of a measure of a likeness (quality) of images; X, Y — images treated and ideal (GT-image); M, N — image sizes

The measure of structural similarity SSIM — a complex estimation of likeness (quality) of images also has following components for comparing of input and output images: correlation coefficient between images, an estimation of likeness of average values of brightness of images, an estimation of likeness of contrasts of two compared images. The above value of a measure of likeness of images, the image handling is better fulfilled.

The criterion of quality of localization at masking which considers both number of ruptures, and number of the passed elements in separate ruptures, and also their small displacement is defined in an aspect:

$$R_{loc} = \begin{cases} \frac{1}{(I_A+N)N} \sum_{i=1}^{I_A} \frac{1}{1+\alpha d^2(i)} \sum_{j=1}^{N} \frac{1}{1+\beta n^2(j)}, N > 0; \\ \frac{1}{I_A} \sum_{i=1}^{I_A} \frac{1}{1+\alpha d^2(i)}, \quad N = 0, \end{cases} \tag{15}$$

where I_A — amount of elements in a real contour; N — amount of ruptures of a real contour in comparison with an ideal contour; α — the factor governing the demanded relation (penalty) for the greased and displaced contour; $d(i)$ — magnitude of displacement of i-th element of the discovered contour on a normal to a line of an ideal contour; β — scale factor (depends on parametres of ruptures in a contour); $n(j)$ — amount of the passed elements in j-th rupture; $\sum_{j=1}^{N} n(j) = I_p$ — amount of the passed elements.

It is possible to draw an output that in practice the task of a combination of various metrics is not less actual, than the task of perfection of determination of existing distinctions.

Conclusions

1. These methods of count estimate are not universal. They have advantages and disadvantages and, as a consequence, restrictions on use.

2. The methods and measures estimation the quality of masking images let a sufficiently detailed quantitative description of the method of masking.

3. The researcher (user) select the method of solving the problem of masking their specific applications, including the most perspective way of comparative testing of existing methods of masking using GT-images.

4. In a joint application of several measures estimation the quality of masking (the quality of detection and localization) needs to consider the consistency of results and the preferences of the interpretation of the evaluation.

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