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КРИТЕРІЙ ОПТИМАЛЬНОСТІ ДЛЯ ВИБОРУ ТА ОПТИМІЗАЦІЇ ПАРАМЕТРІВ СИСТЕМИ ОБРОБКИ ЗОБРАЖЕНЬ

OPTIMALITY CRITERION FOR SELECTION AND OPTIMIZATION OF PARAMETERS OF IMAGE PROCESSING SYSTEM

канд. техн. наук О.А. Герцій
Державний університет інфраструктури та технологій (м. Київ)

O.A. Gertsiy, PhD (Tech.)
State University of Infrastructure and Technology (Kyiv)

The concept of quality efficiency and optimality occupies an important place in theories about information systems in general and image processing systems, as well as for evaluating of information processing methods used in these systems.

The efficiency of the system can be considered as the benefit received as a result of its use, attributed to the costs of its development and operation [1].

Criteria are used to evaluate efficiency. A criterion is an indicator or a measure of the effectiveness of the quality and optimality of the system. Criteria can be private or general [2].

We have to deal with the justification and selection of performance evaluation and optimization criteria at all stages of system modeling. The difficulty of this task lies in the fact that for complex systems it is not possible to choose a single criterion for evaluating efficiency and optimality [3]. Therefore, it is necessary to solve the problem of multi-criteria ranking or optimization, the main thing in this is the choice and justification of the compromise principle, that is, the generalized scalar criterion.

A lot of attention was paid to the construction and development of a system of quantitative measures of the accuracy of monochrome images restoration. It is indicated in [4] that adequate accuracy measures should be consistent with the results of subjective evaluations for a wide class of images, without requiring super complicated calculations. In addition, it is desirable for these measures to have a simple analytical form – then they could be applied as optimality criteria in the optimization or selection of image processing system parameters. The specified requirements are fully consistent with the general requirements for the criteria formulated earlier. Quantitative measures of accuracy of monochrome images restoration can be divided into two groups: single and paired. A single measure is a number that is compared to an image based on an analysis of its structure. A paired measure is a numerical result of a mutual comparison of two images, for example, a reference and a real one [5].

As a criterion of efficiency and optimality of the method we can take the root mean square error of correction.

Let's say $U = \{F(i, j)\}$ - ideal picture, and $i = 1, ..., M$, $j = 1, ..., N$ - coordinates of image elements, M and N - the number of line elements and lines in the frame. The image we observe $V=\{\tilde{F}(x,y)\}$, which was formed as a result of system processing according to a given algorithm of some initial image. The quality of the algorithm will be better in accordance with the match of ideal and resulting image, therefore it is necessary to determine the "closeness of the images".

It is convenient to start with the quadratic measure of closeness - the Euclidean distance. The square of the Euclidean distance between the images is the square of their difference:

$$\|\Delta\|^2 = \sum_{i=1}^{N}\sum_{j=1}^{M}\Delta^2(\mathrm{x},\mathrm{y}), \tag{1}$$

where the difference image is

$$\Delta(\mathrm{x},\mathrm{y}) = V(x,y) - U(x,y). \tag{2}$$

To obtain a measure of the corrective transformation quality for some set of initial images as a whole, which would not depend on the implementation of the disturbance, it is convenient to take the mathematical expectation of the value $\|\Delta\|^2$ (1). By averaging it both over the set of initial images and over different realizations of the obstacle, we obtain the following value:

$$\varepsilon^2 = \left\langle \|\Delta\|^2 \right\rangle = \sum_{i=1}^{N}\sum_{j=1}^{M}\varepsilon^2(\mathrm{x},\mathrm{y}), \tag{3}$$

where $\varepsilon^2(\mathrm{x},\mathrm{y}) = \left\langle (V(x,y) - U(x,y))^2 \right\rangle$, is called root mean square correction error (RMSE).

It can be used as a criterion for the optimality of the correction. The best image is considered to be the one for which the RMSE is minimal. However, such a criterion does not meet the requirement of variability within defined limits, as there are difficulties in establishing its upper limit.

One of the reliability criteria is the normalized root mean square error (NRMSE).

$$NRMSE = \frac{\sum_{i=1}^{N}\sum_{j=1}^{M}[\upsilon\{F(i,j)\} - \upsilon\{\tilde{F}(i,j)\}]^2}{\sum_{i=1}^{N}\sum_{j=1}^{M}[\upsilon\{F(i,j)\}]^2}, \tag{4}$$

where $\upsilon\{\cdot\}$ - a certain (possibly non-linear) operator, $F(i,j)$ - ideal discrete image, $\tilde{F}(i,j)$ - the image under study.

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