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IMPROVING THE ACCURACY OF ESTIMATING THE MEASURE OF PROXIMITY BETWEEN OBJECTS DURING RECOGNITION

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Pattern recognition is very widely used in information and measurement technology for automatic control and diagnostics of technological processes and functioning equipment [1-2].

In pattern recognition, due to the simplicity and speed of calculation, the Manhattan distance is very widely used to estimate the measure of proximity between objects (PMBO) [1]:

$$Z = \sum_{i=1}^{n} |X_i - Y_i|, \quad (1)$$

Where Zi, Xi, and Y_i are, respectively, the value of PMBO, the current values of the features of the recognized and reference image.

Each feature X_i, and Y_i contains the corresponding measurement errors σ_x and σ_y, which, when calculating Z, are added according to a certain law. Therefore, the error in estimating the value of PMBO (σ_{PMBO}) turns out to be greater than the errors σ_x and σ_y. Since the PMBO error is the main parameter in ensuring the reliability of pattern recognition. The latter always turns out to be insufficient. Therefore, increasing the accuracy of the PMBO estimate is relevant.

The article [3] presents the basic principles and variant evaluation of PMBO and found the conditions for minimizing the influence of destabilizing factors on the values of PMBO by mutual correction of errors in measuring the values of features of the recognized and reference images. Proceeding from these principles, in order to minimize the errors in the estimation of the PMBO, the measurement errors of the values of the features of the recognizable σ_x and the reference images should The condition of equality of errors σ_y is feasible, since it is necessary to create an equal and strong correlation both between the value of the features and between the value of the PMBO and the errors σ_x and σ_y be equal in value and sign, and their influence on the value of the PMBO should be the same.

Article [4] proposes a technique for increasing the level of correlation between the errors in measuring the parameters of the recognized and reference images, thereby reducing the error in PMBO estimation. However, this method is effective when the actual values of the parameters of objects are close within acceptable limits and both errors are distributed according to the normal law. Since the results of measuring the parameters of objects are corrected, there may be loss of useful information and distortion of the measurement results. To eliminate these shortcomings, a more advanced technique for increasing the correlation between the results of measuring the parameters of objects is proposed, which is described below.

The essence of the technique lies in the fact that both arrays with the results of measuring the values of the parameters of the recognizable and reference objects are ranked in ascending or decreasing order of their values, and then the PMBO value is estimated by the ranked data arrays. Due to this, individual values of PMBO are formed according to the most correlated pair values of object parameters. This operation makes it possible to increase the correlation between the errors σ_x and σ_y, to equalize the influence of the latter on the PMBO values.

The proposed technique has been verified with the help of a computer, and based on the data obtained, regression models have been built between the output and input data.

These models use the following parameters: ρ_0 and ρ_p – respectively, the correlation coefficients between the errors σ_x and σ_y

before and after ranking arrays of image feature values.

The purpose of computer simulation was to verify the correctness of the proposed method for correcting errors in estimating PMBO values; verification of the effectiveness of the proposed methodology for increasing the correlation between the errors σ_x and σ_y and how many times the error in PMBO estimation decreases; determination of the best computational model for estimating the value of PMBO; determination of important metrological parameters of the process of assessing the value of PMBO.

The constructed models are subject to the following requirements: the calculated value of the F-factor should be high; the error of the linear model should be minimal; parameter coefficient (m_x-m_y) must be equal to one; the coefficients σ_x and σ_y must be equal and close to zero in value and reverse in sign; the intercept and the coefficient of the correlation parameter should approach zero.

To build models that meet these requirements, different arrays of feature values were taken for the recognized and reference arrays with arbitrary and equal error values distributed according to the normal law.

For arbitrary arrays, the results indicated in the following models are obtained. Although after ranking the elements of the arrays, a significant decrease in σ_{PMBO} was obtained, but the models built on these data do not meet these requirements:

$$Z_0 = -15{,}3245 - 0{,}449 \cdot |m_x - m_y| + 1{,}015 \cdot \sigma_x + 0{,}014 \cdot \sigma_y + 23{,}9745 \cdot \rho_0, \quad (2)$$

$$z_p = 0{,}871 - 3{,}79 \cdot |m_x - m_y| + 0{,}19 \cdot \sigma_x + 0{,}08 \cdot \sigma_y + 0{,}203 \cdot \rho_p, \quad (3)$$

Where the indices 0 and p, respectively, denote the data obtained before and after the array elements were ranked. The analysis of these models showed that, due to the difference in the values of σ_x and σ_y, the mutual correction of errors is weak. Nevertheless, when ranking array elements, the corrective effects of errors. σ_x and σ_y on the PMBO values are large and the same. This proves the correctness of the proposed method for correcting errors in PMBO estimation.

To analyze the obtained experimental data, regression models of the dependence:

$\sigma_0 = f(\sigma_x, \sigma_y, p_0)$ and $\sigma_p = f(\sigma_x, \sigma_y, \rho_p)$;

$$\sigma_0 = 12{,}079 + 0{,}316 \cdot \sigma_x + 0{,}035 \cdot \sigma_y - 11{,}753 \cdot p_0; \quad (4)$$

$$\sigma_p = 24{,}272 + 0{,}359 \cdot \sigma_x - 0{,}347 \cdot \sigma_y - 24{,}266 \cdot \rho_p; \quad (5)$$

Regression models of dependencies are also built:

$$Z = f(m_x, m_y, \sigma_x, \sigma_y, \rho),$$

$$Z = f(m_x - m_y, \sigma_x, \sigma_y, \rho),$$

$$Z = f(|m_x, m_y|, \sigma_x, \sigma_y, \rho),$$

$$Z = f(|m_x - m_y|, \sigma_{MBMO}),$$

after the expansion of the element arrays of the values of the attributes of the images:

$$Z_p = -67{,}421 + 0{,}51 \cdot m_x - 0{,}53 \cdot m_y + 21{,}2 \cdot \sigma_x - 21{,}07 \cdot \sigma_y + 67{,}17 \cdot \rho_p, \quad (6)$$

$$Z_p = 2{,}508 + 0{,}5 \cdot (m_x - m_y) + 10{,}62 \cdot \sigma_x - 10{,}93 \cdot \sigma_y - 2{,}444 \cdot \rho_p, \quad (7)$$

$$Z_p = -0{,}001 + 1{,}0001 \cdot |m_x - m_y| + 0{,}303 \cdot \sigma_p, \quad (8)$$

$$Z_p = -0{,}0452 + 0{,}99996 \cdot |m_x - m_y| - 0{,}238 \cdot \sigma_x - 0{,}237 \cdot \sigma_y + 0{,}04599 \cdot \rho_p, \quad (9)$$

As can be seen from the parameters of the model (4), it cannot be used to estimate the PMBO values, since it has a large root-mean-square error and asymmetric correlation coefficients between the output parameter and the parameters m and σ of the recognized and reference images.

Model (5) also has a large mean square error of 86,8% and asymmetric correlation coefficients between the output parameter and the parameters of the recognized and reference images.

Analysis of the parameters of these models showed that the best of them are (8) and (9). They fully confirm theoretical studies. In model (8), the root-mean-square error is 0,047%; the correlation coefficients between the output parameter and the arguments are quite high and symmetrical. The calculated value of the F criterion is 4228359,00. In model (9), the root-mean-square error is 0,0897%; the correlation coefficients between the output parameter and the arguments are quite high (0,99998 and -0,7513). The calculated value of the F-criterion is 56710,00.

Conclusion

Thus, from the results obtained, the following conclusions can be drawn:

- this technique allows to significantly increase the correlation between the measurement errors of the values of the features of the recognized and reference images;
- the error in estimating the PMBO really decreases with an increase in the correlation coefficient between the errors σx and σy, and when using this technique, it is more than 3 times;
- the derived experimental formulas (8) and (9) are fully consistent with the theoretical formula [3] and can be used in practical applications of the Manhattan distance to estimate PMBO in pattern recognition;
- model (9) more clearly reflects the process of estimating the PMBO and shows the exact dependence of the value of the latter on the errors σ_x and σ_y of the correlation between them ρ and the advantage of the invariant estimator of the PMBO;
- a slight difference between models (8) and (9) from the ideal one is due to the linearity of the constructed models.

References

1. *Faure A.* Perception and pattern recognition / Translated from French. A.V. Seredinsky. Under the editorship of G.P. Katys.M. // Mechanical Engineering. – 1989. – 272 p.
2. *Mamedov R.K.* Analysis of methods for improving the reliability of image recognition by technical vision systems. Automation and modern technologies. – 1998. – No. 9. – P. 21-26.
3. *Mamedov R.K.* Fundamentals of building vision systems with invariant image recognition. Automation and modern technologies. – 1998. – No. 6. – P. 9-12.
4. *Mamedov R.K.* Using the Euclidean distance for an accurate assessment of the measure of proximity between objects in pattern recognition. Metrology. – 1998. – No. 3. – P. 10-14.

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The article analyzes the problem of the occurrence of errors in measuring the geometric parameters of objects in pattern recognition, possible ways to minimize them, and as a result of this analysis, an algorithm is proposed for effectively increasing the reliability of pattern recognition by adequately estimating the measure of proximity between recognized and standard objects. The article considers a model for the process of estimating the measure of proximity between objects and the resulting errors, proposes conditions and an algorithm for *minimizing these errors, and recommends measures to improve the accuracy of estimating the measure of proximity between objects.*

Keywords: *pattern recognition, proximity measures between objects, error, recognition reliability, invariance.*

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ПІДВИЩЕННЯ ТОЧНОСТІ ОЦІНКИ МІРИ БЛИЗЬКОСТІ МІЖ ОБ’ЄКТАМИ ПІД ЧАС РОЗПІЗНАВАННЯ

У статті аналізується проблема виникнення помилок при вимірюванні геометричних параметрів об’єктів при розпізнаванні образів, можливі шляхи їх мінімізації, і в результаті цього аналізу запропоновано алгоритм ефективного підвищення надійності розпізнавання образів шляхом адекватної оцінки міра близькості між розпізнаними і стандартними об'єктами. У статті розглядається модель процесу оцінки міри наближення об’єктів та результуючі похибки, запропоновані умови та алгоритм мінімізації цих похибок, а також рекомендовані заходи для підвищення точності оцінки міри наближення між об’єктами.

Ключові слова: *розпізнавання образів, міри наближення між об’єктами, похибка, надійність розпізнавання, інваріантність.*