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HAND-WRITTEN CHARACTER STRUCTURE RECOGNITION TECHNOLOGY ON THE BASIS OF IDENTIFICATION MEASUREMENTS

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ABSTRACT

This article describes the technology of recognizing the structure of handwritten characters converting the input image into a binary file and comparing it with a set of similar precedent files. The efficiency of application of the parameters determined by the solution of the logistic curve, which integrally characterize the distribution form, virtual frequency and degree of randomness of signals, is established. The article describes a device designed by artificial intelligence technology with the following channels: input image and standards, measurement and logical analysis. Based on the research results, the efficiency of the technology is shown and the structure of the character recognition system with the accumulation of statistical information is proposed.

Keywords: database, identification, measurement, images, recognition, signal, structure, technology, numbers.

INTRODUCTION

In the era of the rapid development of info-communication technologies, the creation of sustainable information processing systems, identity identification and authentication with handwriting and character recognition technologies have become an urgent task. In particular, the recognition of handwritten numbers is relevant when passing exams by applicants when they enter the answer number with a pen in a certain, formatted in size, field of the task form.

However, the problem of efficient and high-precision recognition is not finally solved, because there are a number of problems caused by the following factors of handwriting: lack of standards, individuality, commitment to various distortions and chaotic writing.

The following operations are used for computer recognition: 1) reading the image of a digit into memory; 2) formatting the image to reduce the impact of variability of the font; 3) converting the image into a text file and filtering it; 4) comparing the input image file and the files of reference images; 5) deciding on the degree of belonging of the studied image to the reference one.

The most important and complex stages from an information point of view are those numbered 4 and 5. Numerous problems arising in this case are solved, as a rule, from the position of the Theory of Pattern Recognition (classification theory) [1]. Currently, the most promising way to solve the problem of recognition of handwritten characters lies in the application of artificial neural networks (ANN) technology [2, 3]. In this regard, various algorithms are proposed, with the help of which the authors try to reduce the impact of the main disadvantages of ANN, which include: the ambiguity of choice and complexity of the structure [4], the problem of training (tasks and settings of weight coefficients) [5], the formation of a database of precedents, etc. [6]. In the end, the cost of such computer systems (for example, FineReader) increases so much that their local application is ineffective.

In this paper, the aim was to offer a completely new technology of recognition of handwritten images, based on the representation of information in the form of a logical structure such as a relational database (RDB) with the ability to control the information system using relational algebra operations. On the example of solving the problem of recognition of handwritten numbers, to show the main stages, features, and effectiveness of the technology of representation of their structure.

DESCRIPTION OF THE RECOGNITION TECHNOLOGY

The idea of the proposed technology is based on converting the input image into a binary file and comparing it with a set of similar precedent files. Structurally, the technology is described by the scheme shown in Figure-1, and includes input image (IIC) and standards (ISC) channels, measurement channel (MC) and logical analysis channel (LAC).

Precedents are formed by randomly selecting the previous (past) handwritings of the corresponding digits, which act as standards and are stored in the unit of standard images (USI), organized as a primary database. The preprocessing unit (PPU) of ISC converts a two-dimensional image of a digit into a one-dimensional sequential text file according to the principle: "The last character (0 or 1) of one line is followed by the first character of the next line." The scanning device (SD) controls USI and PPU, and provides a sequential output of text files of stored standards.

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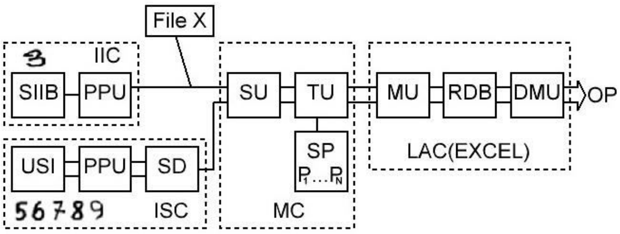

Figure-1. Block diagram of the handwriting recognition system.

The recognizable handwritten image of the handwriting symbol is entered through the input block (SIIB) of the IIC. Then it is converted from a two-dimensional image into a one-dimensional sequential text file X(j) also in the preprocessing unit (PPU).

In the subtraction unit (SU), the file X (j) is subtracted from the reference files, forming an array of corresponding type differences for each reference:

$$\Delta(i,j) = X(j) - Y(i,j). \qquad (1)$$

In this expression $1 \le i \le M$ is the number of standards, $1 < j < L$ is the number of samples of values in comparison files.

Each difference Δ (i, j) is measured in the tester unit (TU) basing on the parameters (P1, P2, .., PN), the number of N is entered into the system through a specialized setpoint (SP), and the algorithm is programmed.

An important feature of the system is the choice of measurement parameters (P1-P9). In this system, the so-called identification parameters (IdP) are used, which integrally characterize the distribution form, virtual frequency and degree of randomness of the signals represented by the differences Δ (i, j). Their choice is due to the application of the law of the "reverse" solution of the iterative equation describing the features of the fractal process of population change - the Verhulst process [7].

The following identification parameters are used for conversion:

a) P1 is the form parameter calculated for the difference signal Δ (i, j) by the formula:

$$P1 = 2N\frac{|\overline{\Delta X_2}|}{|\overline{X_2}|}, \qquad (2)$$

where N is the sample size of the signal signaled Δ(i, j), $|\overline{X_2}|$ is the average of the ranked functions signaled Δ(i, j), $|\overline{\Delta X_2}|$ is the mean value of increments ranged function of a signal Δ(i, j);

b) P2 is the average value of the virtual frequency of the signal difference Δ (i, j):

$$P2 = \frac{|\overline{\Delta X_1}|}{|\overline{\Delta X_2}|} \qquad (3)$$

where $|\overline{\Delta X_1}|$ is the average value of signal increments Δ (i, j);

c) P3 is the ratio of P2 to the value of the virtual frequency of the periodic signal Fgen, while their distribution forms in accordance with the principles of equivalence of signals should be equal, for example: the distribution form of the periodic sinusoidal signal is equal to the distribution form of the random arcsinus signal Asin = Aasin = 6.28 radians;

d) P4, P5, P6 are the same parameters as P1, P2, P3, but calculated not for the difference signal Δ (i, j), but for the autocorrelation function of the difference signal;

e) P7 is the average value of parameters P1, P2, P3;

f) P8 is the average value of parameters P4, P5, P6;

g) P9 is the standard deviation of the signal of difference Δ (i, j) - this parameter is statistical.

The numerical values of the difference signal parameters are temporarily recorded in the memory unit (MU) of the LAC. Further, as a result of their systematization, they are transferred to a relational database (RDB), in accordance with the classical representation of information in the structure of DBMS (database management systems), where the rows are called records, and the columns are called fields [8]. RDB is a two-dimensional table of numerical values of difference parameters. Table-1 describes an example RDB with a representation of the results of observations of some input file named 425.txt with a part of the matrix containing 10 standards of writing the symbol 0 and 5 standards of the symbol 1.

In Table-1, the headers form the names of the following fields: No. is the sequence number of the record, Files are the designation of the names of the compared signals (input - 425.txt) and one of the reference (for example, 0\0_1) taken from USI. The names of the fields (P1,..,P9) combine the results of quantitative measurements of the corresponding records.

The application of DBMS rules allows using the whole range of relational algebra operations and, in particular, sorting and filtering of records to solve the problem of handwriting recognition.

The difference between the pixel values of the input and reference files is a directly observable value. If we denote the number of standards of each digit (precedents) of the database by M, then min(M) = 10 - according to the number (from 0 to 9) of varieties of the ideal representation of digits, and max(M) is unlimited. In particular, if to set 10 variants of writing to each digit (max(M) = 100), and to use N = 9 measured parameters, we will receive the multidimensional result of observations represented by a matrix (of dimension M*N) consisting of 100 lines and 9 columns.

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Table-1. Presentation of the observation results.

No.	Files	P1	P2	P3	P4	P5	P6	P7	P8	P9
1	425.txt & новая_БД\0\0_1.txt	9.601	336.885	4.159	43.279	156.05	5.797	116.88	68.37	0.6162
2	425.txt & новая_БД\0\0_10.txt	10.12	341.2	4.086	42.536	156.48	6.292	118.47	68.44	0.6204
3	425.txt & новая_БД\0\0_2.txt	9.28	333.225	4.114	39.769	166.17	6.086	115.54	70.67	0.6087
4	425.txt & новая_БД\0\0_3.txt	10.42	305.903	3.922	52.192	128.38	5.508	106.75	62.03	0.5779
5	425.txt & новая_БД\0\0_4.txt	9.972	344.608	4.203	42.118	164.05	7.117	119.59	71.1	0.6255
6	425.txt & новая_БД\0\0_5.txt	9.038	361.623	4.437	42.08	160.11	5.275	125.03	69.15	0.6448
7	425.txt & новая_БД\0\0_6.txt	11.56	313.275	3.892	44.965	150.14	4.809	109.58	66.64	0.5867
8	425.txt & новая_БД\0\0_7.txt	11.11	303.125	3.63	49.329	134.84	5.323	105.96	63.16	0.5744
9	425.txt & новая_БД\0\0_8.txt	10.62	321.658	3.875	47.584	141.26	5.092	112.05	64.65	0.597
10	425.txt & новая_БД\0\0_9.txt	8.87	371.42	4.614	34.937	187.66	6.383	128.3	76.33	0.6555
11	425.txt & новая_БД\1\1_1.txt	8.535	385.075	5.581	30.35	225.38	8.129	133.06	87.95	0.6742
12	425.txt & новая_БД\1\1_10.txt	8.928	364.06	5.092	33.139	196.89	6.999	126.03	79.01	0.6468
13	425.txt & новая_БД\1\1_2.txt	7.47	407.25	6.078	28.278	235.43	7.443	140.27	90.38	0.702
14	425.txt & новая_БД\1\1_3.txt	8.461	374.678	6.092	30.82	218.08	6.539	129.74	85.15	0.6605
15	425.txt & новая_БД\1\1_4.txt	7.905	369.615	5.914	21.519	302	8.1	127.81	110.5	0.6525

In order to obtain an effective result, there was included a decision-making unit (DMU), which recognizes the image of the input signal, correctly formulating the analysis task taking into account the peculiarities of the RDB under consideration, forming an output proposition (OP).

The peculiarity of the recognition technology is that the multidimensional nature of RDB is the main source of uncertainty (ambiguity) of the obtained analysis results. For example, if we sort Table-1 in ascending order (SortUp) of values by parameter P1, we get the structure shown in Figure-2 (for the first four fields No, Files, P1, P2). In this case, one solution may be the assumption: "It is possible that the input file 425.txt displays the digit **9** as P1 = min = 7.29868". That is, the closest of the three distances is the distance to the digit 9.

№	Files	P1	P2
100	425.txt & новая_БД\9\9_9.txt	7,29868	404,245
77	425.txt & новая_БД\7\7_6.txt	7,33037	414,595
13	425.txt & новая_БД\1\1_2.txt	7,46994	407,25

Figure-2. Example of display of observation results (Table-1) in ascending order (SortUp) of values on P1 parameter.

If we carry out a similar sorting by parameter P2, we get the structure shown in Figure-3.

№	Files	P1	P2
68	425.txt & новая_БД\6\6_7.txt	16,6888	178,9325
67	425.txt & новая_БД\6\6_6.txt	14,1244	198,2075
69	425.txt & новая_БД\6\6_8.txt	13,4003	219,99

Figure-3. Example of display of observation results (Table-1) in ascending order (SortUp) of values on P2 parameter.

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In this case, the solution may be the proposition: "It is possible that the input file 425.txt displays the digit 6 as P2 = min = 178.9325".

Comparing the examples (Figures 2 and 3), we note an important property that can be used to form a decisive rule that reduces the ambiguity of recognition: "Find such a combination of estimates of the measured parameters (P1,..,P9), for which the database sorting (SortUp-ascending or SortDown-descending) provides the maximum representation of standards (precedents) of one class (one digit)."

For the above examples, the application of this rule allows making the final conclusion that "Input file 425.txt displays the number 6, because when sorting the SortUp parameter P2, three identical digits (6) are extracted from the database, while when sorting the parameter P1, three different (9, 7 and 1) digits are extracted from the database."

The results of the analysis of the full database parameters (P1-P9) are presented in Table-2, which takes into account the number of identical digits in a continuous sequence of records.

Table-2. Distribution of digits (0, 1, 2, 3, 6, 9) by parameters (P1 - P9) when sorting the database in ascending (Sort Up) and descending (Sort Down) order.

Parameters	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
Sort Up	9	6	6	1	6	0	6	6	6
Sort Down	6	2	1	6	1	3	2	1	2
Qty Up	1	7	6	4	6	1	7	6	7
Qty Down	4	1	1	6	4	1	1	4	1

The results presented in Table-2 are given in Table-3, in a more visual (spectral) form. Since in table 3 each digit makes its own contribution to the spectrum, it is natural that the desired digit is best identified by the maximum of the integral estimate Up & Down = (Up)*(Down). In this case, the operation of multiplication of partial spectra is used as an analogue of the logical bundle "And". At the same time, the accuracy of recognition of the digit 6 in the example is D=max/sum=0.915493. The final answer can be written in the form of the following proposition: "Input image X represented by file 425.txt, corresponds to digit 6 with a confidence of 0.915493" or in a short entry: «X = 6/0.915493».

Table-3. Spectral Representation of Analysis Results in DMU.

Digits	**Up**	**Down**	**Up & Down**
0	1	0	0
1	4	9	36
2	0	3	0
3	0	1	0
4	0	0	0
5	0	0	0
6	39	10	390
7	0	0	0
8	0	0	0
9	1	0	0
Sum	45	23	426
D=max/sum	0.867	0.435	0.915493

The actual image of the digit **6** for the file 425.txt is shown in Figure-4.

Figure-4. Real image of the digit 6 (file 425. txt).

To conduct experimental studies on the approbation of recognition technology, a research computer device (CD) was developed in the LabVIEW10 environment, the external control panel of which is shown in Figure-5. CD is built on artificial intelligence technology and includes all elements of the recognition system presented in Figure-1, including the ability to increase the number of precedents (standards). This will increase the probability of correct recognition, in the limit, aiming at 1. The proposed CD structure uses N=9 parameters, but it is possible to increase their number. The control panel displays graphical images of binary signals and a table with measurement results, which is also presented in electronic format in the form of EXCEL tables for logical analysis in the LAC. Currently, the USI database has records of more than 100 people with different handwriting characteristics.

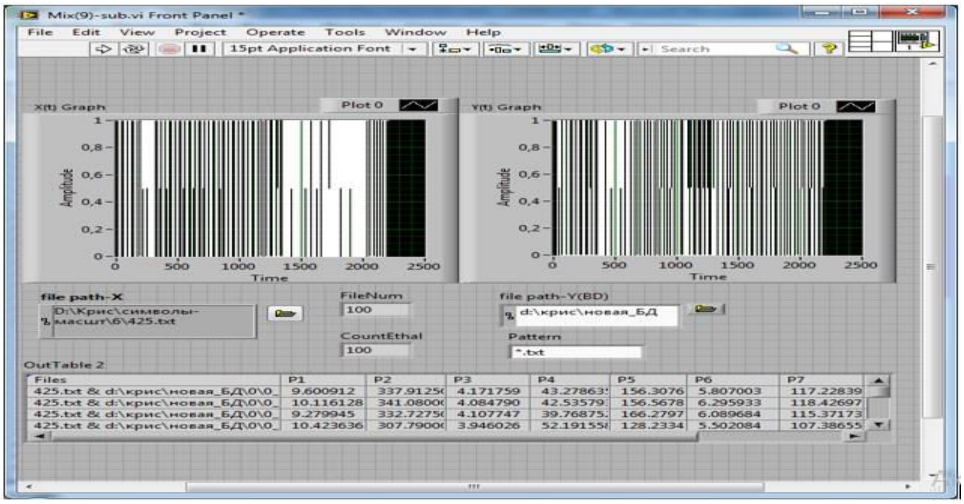

Figure-5. Control panel for the system of recognition of handwritten digits.

RESEARCH RESULTS

As a result of the conducted researches for a group of images of handwritten figures, the complex of graphic characteristics and numerical values of parameters which analysis allowed to draw the following conclusions was received.

1 To justify the choice of parameters for the measurements of handwritten symbols, the identification parameters (P1, P2, P3, and P7) were replaced with classical, statistical parameters in accordance with the rules shown in Table-4.

Table-4. Comparative parameters of the measuring part of the system.

No.	Identification Parameters (IdP)	Statistical Parameters
1	P1-signal form Δ (i, j)	Root-Mean-Square Deviation RMSD (i, j)
2	P2 is the virtual frequency of the signal Δ (i, j)	Mathematical expectation (M) of the signal Δ(i, j)
3	P3 parameter of signal regularity Δ(i, j)	Correlation (R) of the signal Δ(i, j)
4	The average value of parameters P1..P3	The average value of parameters 1..3

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Table-5. Fragment of RDB state when using identification parameters.

No.	Files	P1	P2	P3	P7
68	425.txt & новая_БД\6\6_7.txt	16.68879	178.9325	2.690714	66.104
67	425.txt & новая_БД\6\6_6.txt	14.12441	198.2075	2.914816	71.74891
69	425.txt & новая_БД\6\6_8.txt	13.40031	219.99	3.259111	78.88314
61	425.txt & новая_БД\6\6_1.txt	11.86029	222.13	3.417385	79.13589
64	425.txt & новая_БД\6\6_3.txt	12.10844	239.655	3.744609	85.16935
65	425.txt & новая_БД\6\6_4.txt	11.75136	241.9625	3.384091	85.69932
66	425.txt & new_bd\6\6_5.txt	14.37192	241.78	3.429504	86.52714
60	425.txt & новая_БД\5\5_9.txt	12.34264	258.47	3.773285	91.52864
70	425.txt & новая_БД\6\6_9.txt	10.71462	271.105	3.957737	95.25912
59	425.txt & новая_БД\5\5_8.txt	11.90631	272.345	4.157939	96.13642
58	425.txt & новая_БД\5\5_7.txt	11.903	275.3125	4.171402	97.12897

Table-6. Fragment of the of the DB state when using statistical parameters.

No.	Files	P1	P2	P3	P7
		STD(X-Y)	M(X-Y)	Corr(X;Y)	mean
35	425.txtg:\новая_БД\3\3_5.txt	0	0	0.845684	0.281895
36	425.txtg:\новая_БД\3\3_6.txt	0.063844	0.004091	0.781689	0.283208
10	425.txtg:\новая_БД\1\1_1.txt	0.161588	-0.02682	0.729615	0.288128
94	425.txtg:\новая_БД\9\9_4.txt	0.16682	-0.02864	0.732279	0.290154
12	425.txtg:\новая_БД\1\1_2.txt	0.280964	-0.08636	0.710557	0.301719
59	425.txtg:\новая_БД\5\5_9.txt	0.261238	-0.07364	0.732946	0.306849
17	425.txtg:\новая_БД\1\1_7.txt	0.189472	-0.03727	0.771248	0.307816
45	425.txtg:\новая_БД\4\4_5.txt	0.164228	-0.02773	0.794749	0.310417
8	425.txtg:\новая_БД\0\0_8.txt	0.175556	-0.03182	0.788984	0.310907
7	425.txtg:\новая_БД\0\0_7.txt	0.208346	-0.04546	0.769847	0.310913
6	425.txtg:\новая_БД\0\0_6.txt	0.056331	0.003182	0.877444	0.312319

10 variants of writing a number (from 0 to 9) of handwritten digits were tested. Tables 5 and 6 show the first 10 records sorted in ascending order (SortUp) of RDB records by P7 indicator.

At the same time, eight out of ten (80%) records in Table-5 indicate the correct (see Figure-4) digit (6), while the top two entries point to Figure-3 in Table-6, which is an error. This shows that the use of identification indicators as measurement parameters leads to correct and statistically reasonable conclusions on the belonging of the studied image to accepted standards.

2. The recognition results for 10 variants of writing handwritten digits-Tests (Table-7) allow putting forward two hypotheses: first, the value of the maximum Up&Down determines the correctness of the result, if it is not less than about 0.454; secondly, the higher this value, the higher the quality of writing the character, as evidenced by the result of recognition of the digit **0** in Table-7 (lines 2 and 7) - the quality of correct recognition of this digit is higher for file 422.txt (0.784) than for file 427.txt (0.504).

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Table-7. Summary of the recognition results.

No.	File Name	Correct Digit	Digit corresponding to the maxUp & Down of the spectrum	max value	Note
1	421.txt	1	1	0.455	Correct
2	422.txt	0	0	0.784	Correct
3	423.txt	4	4	0.583	Correct
4	424.txt	1	1	0.96	Correct
5	425.txt	6	6	0.915	Correct
6	426.txt	3	3	0.672	Correct
7	427.txt	0	0	0.504	Correct
8	428.txt	2	2	0.886	Correct
9	429.txt	4	4	0.571	Correct
10	430.txt	1	2	0.381	Error

There is also an erroneous result (Table-7, line 10, file 430.txt), although the resulting recognition file 430.txt, where there are two adjacent peaks, differing from each other by about 10%: the correct result (0.2857143) corresponds to digit 1 and the incorrect result (0.3809524) corresponds to digit 2. Therefore, in order to choose the correct result, it is necessary to use some additional methods of filtering the database or introduce correction algorithms.

4. A new method of correction of recognition results is proposed, the essence of which is as follows: 1) a source file is analyzed with an unknown image as described above and the position of the maximum of the spectrum Up&Down is determined by the possible figure; 2) if there are doubts about the recognition, the original file is written to the primary RDB as a reference; 3) the original file is re-examined with an unknown image with the updated composition of RDB and position of the spectrum maximum of Up&Down is determined by the figure, which is included in the OP.

As an example, let us consider the results of recognizing a digit contained in file 440.txt. Figure-6 shows two tables, the left displays the membership spectrum of the original (uncorrected) file 440.txt. As can be seen, a possible solution would be to decide in favour of digit 1.

440.txt				440C.txt			
Цифры	Up	Down	Up&Down	Цифры	Up	Down	Up&Down
0	0	0	0	0	1	8	8
1	8	14	112	1	6	0	0
2	6	8	48	2	3	1	3
3	0	0	0	3	0	0	0
4	3	0	0	4	0	0	0
5	0	0	0	5	0	0	0
6	2	5	10	6	1	0	0
7	0	0	0	7	0	0	0
8	0	0	0	8	0	0	0
9	0	0	0	9	0	0	0
sum	19	27	170	sum	11	9	11
D=max/sum	0.421053	0.518519	0.658824	D=max/sum	0.545455	0.888889	0.727273

Figure-6. Results of comparison of the same image in the mode without correction (table on the left) and with correction (table on the right).

The right table was obtained using the correction mode (file 440C), in which the source file was included in the main RDB. Since the confidence score (0.727) of selecting digit 0 is higher than the confidence score (0.659) of selecting digit 1 (file 440), the solution uniquely points to digit 0.

In practical use of the considered recognition system, the correction mode must be enabled by default in the main operating mode of the system. We shall note that in this case, the main RDB will be adaptively updated with new standards and, accordingly, the reliability of handwritten digits recognition will increase.

CONCLUSIONS

As a result of the conducted research it was established that it is possible to carry out successfully recognition and structural representation of handwritten symbols on the basis of transformation of an input image into a binary file and comparison it with a set of similar files of precedents. Application of identification parameters of measurement is effective and reasonable at recognition of handwritten digits that confirms prospects of application of the offered technology in systems of information processing, identification, and authentication.

The possible increase in recognition efficiency is due to the use of new filtering methods and correction algorithms. The direction of further research should be focused on building RDB, the study of the possibility of identification measurements of other than autocorrelation characteristics of the difference signal, such as wavelet and spectral, and the development of new technologies for filtering and correction.

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REFERENCES

[1] Sasan Karamizadeh, Shahidan M. Abdullah, Mazdak Zamani and Atabak Kherikhah. 2014. Pattern recognition techniques: studies on appropriate classifications. ARPN Journal of Engineering and Applied Sciences. 9(8): 1215-1219.

[2] Dikiy D. I. and Artemeva V. D. 2017. Research of artificial neural network applicability for user's online handwritten signature verifications. Scientific and technical journal of information technologies, mechanics and optics. 17(4): 677-684.

[3] Bayram Annanurov and Norliza Mohd. Noor. 2018. Khmer handwritten text recognition with convolution neural networks. ARPN Journal of Engineering and Applied Sciences. 13(22): 8828 8833.

[4] Jomy J., Pramod K. and Kannan B. 2012. Unconstrained hand-written Malayalam character recognition using wavelet transform and support vector machine classifier. Procedia Engineering. 30: 598-605.

[5] Bal A. and Saha R. 2016. An Improved Method for Handwritten Document Analysis Using Segmentation, Baseline Recognition and Writing Pressure Detection. Procedia Computer Science. 93:403-415.

[6] Li S. 2011. Handwritten character recognition technology com-bined with artificial intelligence. Journal of Discrete Mathematical Sciences and Cryptography. 20(1): 167-178.

[7] Koshekov K. T., Klikushin Yu. N., Kashevkin A. A., Latypov S. I., Sofina N. N., Savostina G. V., Koshekov A. K. 2018. An Intelligent System for Vibrodiagnostics of oil and Gas Equipment. Russian Journal Non-destructive Testing. 54(4): 249-259.

[8] Makshanov A., Zhuravlev A. 2018. Intelligent Data Analysis Technologies. Publishing house: Lan. p. 212.