Information Technology of Forming the Quality of Art and Technical Design of Books

Oksana Sichevska[1][0000-0002-1239-206X], Vsevolod Senkivskyy[1][0000-0002-4510-540X], Sergii Babichev[1,2][0000-0001-6797-1467], Orest Khamula[1][0000-0003-0926-9156]

[1]Ukrainian Academy of Printing, Lviv, Ukraine
mag_oks@ukr.net, senk.vm@gmail.com, khamula@gmail.com

[2]Jan Evangelista Purkyne University in Usti nad Labem, Usti nad Labem, Czech Republic
sergii.babichev@ujep.cz

Abstract. The paper presents a structural and functional model of information technology for forming the quality of art and technical design of book at the stage of prepress preparing. The basis of the proposed technology is a fuzzy knowledge base which allows us to build the relationships between physically separated variables during the process of art and technical design of books by the use of both the means of mathematical theory of fuzzy sets and distinguished factors for prepress preparation of books. A fuzzy knowledge matrix for linguistic variables *H* – "quality of art design of books" which contain the linguistic variables *G* – "quality of art decoration" and *R* – "quality of technical design" have been formed and presented as the tables. The systems of fuzzy logical equations which determine the procedures of obtaining the weights of membership functions for a set of linguistic terms are developed and calculated. The defuzzification procedure has been performed for all linguistic variables considering the table of the membership functions normalized values in the three points of the universal set division. It has been proposed the quantitative indicator of the level of the predicted quality of the printing process by the implementation of defuzzification procedure of the output fuzzy set using the mass center method. The numerical value of the level of quality of art and technical design of books H = 52,5% has been obtained during the simulation process.

Keywords: integral quality index, fuzzy knowledge base, linguistic variable, art and technical design of books, prepress preparing

1 Introduction

During a lot of time, from the beginning of creation to the present time, the book has undergone a long stage of its identity forming. Considering the stages of becoming a book, we can select several important processes which form its quality. For example, the perception of content is determined by the design of the publication or the visual factors which come into at the stage of transforming the author's work into a print edition. The process of art and technical design belongs to the stage of prepress preparation of publications [1]. Research in this subject area allows us to present the

2019 DCSMart Workshop.

publishing process in the form of information-technological system with the use of a system approach to improving the functioning of the publishing house for purpose of quality execution of a complex of publishing procedures.

Investigation concerning formation of quality of technical design of books can be performed based on the applying of mathematical theory of fuzzy sets within the framework of fuzzy logic inference system [2] using the modern tools and techniques of scientific research, as well as processes and factors that have different dimensions (numerical, conditional, qualitative). Nowadays, there are a lot of works which are devoted to the issues of fuzzy logic inference systems implementation for various purposes in different fields of research [3-17]. However, it should be noted that the authors' research are mainly focused on small dimension data processing in order to create fuzzy logic inference system for direction and control the appropriate object functioning. Implementation of the fuzzy logic inference system for evaluation of the prepress process quality create the conditions for complex estimation of various factors influence on integral parameter, which determines the quality of the book prepress preparing. The application of the fuzzy logic theory to the evaluation of the prepress quality assumes the following: formation of a set of linguistic variables (LV) that determine the quality of the prepress process; formalization of input parameters into linguistic variables, i.e. identification of recommended ranges of values of universal term sets and linguistic terms of art and technical design of book publications; creation a model of integral quality index formation which include both calculation of membership functions (MF) of linguistic variables and formation of rules base agreed between input variables and output parameter.

The issues devoted to prepress of books based on fuzzy logic technique are considered in [18–22]. So, in [18,19] the authors considered the process of realization of mounting descents. The paper [20] presents the results of research concerning formation of quality of designing and structuring of publications. Issues concerning formation integral prediction of the book publication quality are considered in [21]. The paper [23] presents the result of the research concerning quality assurance of publishing and printing processes. However, it should be noted that despite of achievement in this subject area, there are some unsolved tasks. For example, the prognostic evaluation of the quality of the investigated process considering a unified methodological basis, whose main components are the methods based on the theory of hierarchical multilevel systems, simulation techniques, study of operations and fuzzy sets, remains insufficiently studied nowadays.

The aim of the paper is development of information technology of forming the quality of art and technical design of book publications, the basis of which are both a fuzzy knowledge base and a system of fuzzy logical equations, which are the basis to determine an integral indicator of the quality level of art and technical design of publications.

2 Formal Problem Statement

Fig. 1 presents the structure block-chart of fuzzy inference process.

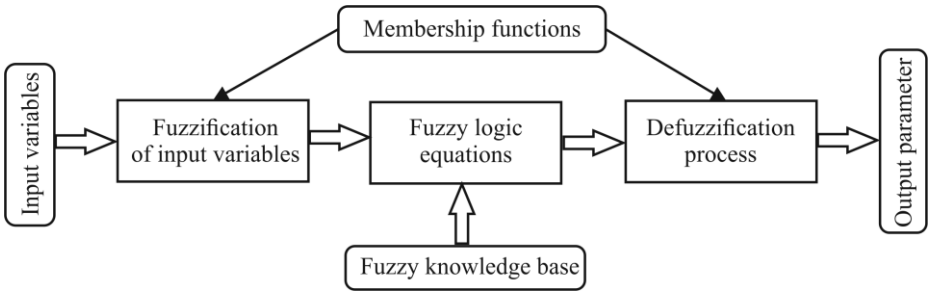

Fig. 1. Structural block-chart of fuzzy inference process

Its implementation assumes the following steps:

- formation of a set of input variables and output parameter;
- formalization of both the input variables and output parameter. Formation of a basic term-set of the input variables and output parameter with corresponding membership functions for each of the terms;
- formation of a set of fuzzy rules agreed with the input variables and output parameter;
- creation of the fuzzy logic equations for fuzzy inference process implementation;
- development of the method for defuzzification process implementation.

3 Formation of Fuzzy Knowledge Base and Fuzzy Logical Equations

A fuzzy knowledge base (FKB) is a set of fuzzy rules "if-then" which determine the relationship between the inputs and outputs of the investigated object and realize the investigated relationships between natural language factors using fuzzy set theory and linguistic variables. This allows us to build relationships between physically separated quantities during the process of art and technical design of books. A logical continuation of the formed fuzzy knowledge base is creation of a system of fuzzy logic equations which determine the procedures of obtaining the weights of the membership function for the set of linguistic terms of the integral quality index of the corresponding process and, as the result, its calculation.

The FKB is formed considering the expert assessments concerning influence of factors to the process of the book design. Moreover, the fuzzy knowledge base determines the algorithm of predicted quality formation based on combinations of values of linguistic terms (LT). Thus, the FKB can be represented as the set H – "quality of art and technical design of book editions" with linguistic terms LT – "Low, Medium, High". The next step is formation of the linguistic variables (LV) sets: G – "quality of the art design" and R – "quality of the technical design" with LT – "Low, Medium, High".

Considering the models of integral quality index formation [24], we can form the FKB as a set of fuzzy rules. This fuzzy knowledge base is presented in table 1.

Table 1. Knowledge base for language variable *H*

Quality of art design *(G)*	Quality of technical design *(R)*	Quality of art and technical design *(H)*
Low	Low	Low
Low	Medium	
Medium	Low	Medium
Medium	Medium	
High	Medium	High
High	High	

The fuzzy knowledge base, presented in table 1, allows us to form the fuzzy logic equations in order to calculate the values of membership functions of terms which determine an integral index of the publication design process quality. These equations are presented below:

- for term "Low":

$$\mu_{Low}(H) = \left(\mu_{Low}(G) \wedge \mu_{Low}(R)\right) \vee \left(\mu_{Low}(G) \wedge \mu_{Med}(R)\right);$$

- for term "Medium":

$$\mu_{Med}(H) = \left(\mu_{Med}(G) \wedge \mu_{Low}(R)\right) \vee \left(\mu_{Med}(G) \wedge \mu_{Med}(R)\right);$$

- for term "High":

$$\mu_{Hg}(H) = \left(\mu_{Hg}(G) \wedge \mu_{Med}(R)\right) \vee \left(\mu_{Hg}(G) \wedge \mu_{Hg}(R)\right).$$

The fuzzy knowledge base for the next level, for both the *G* and *R* linguistic variables are presented in table 2 and table 3. The fuzzy logic equations which are formed based on both the table 2 and table 3 are presented below. These equations allow us to calculate the membership functions for linguistic variables *G* and *R* respectively.

Table 2. Knowledge base for language variable *G*.

Graphical illustration methods *(g_1)*	Complexity of the edition structure *(g_2)*	Layout of the edition *(g_3)*	Quality of art design *(G)*
Line-art graphics (l_art)	Complicated (compl)	Simple	Low
Continuous-tone (ct)	Simple	Simple	
Line-art graphics (l_art)	Simple	Complicated (compl)	Medium
Continuous-tone (ct)	Complicated (compl)	Simple	
Art graphics (art)	Simple	Complicated (compl)	High
Continuous-tone (ct)	Complicated (compl)	Complex	

Linguistic equations for determine the values of the membership functions for *G* variable:

- for term “Low”:

$$\mu_{Low}(G) = \left(\mu_{l\_art}(g_1) \wedge \mu_{\text{compl}}(g_2) \wedge \mu_{\text{simple}}(g_3)\right) \vee \\ \vee \left(\mu_{ct}(g_1) \wedge \mu_{\text{simple}}(g_2) \wedge \mu_{\text{simple}}(g_3)\right);$$

- for term “Medium”:

$$\mu_{Med}(G) = \left(\mu_{l\_art}(g_1) \wedge \mu_{\text{simple}}(g_2) \wedge \mu_{\text{compl}}(g_3)\right) \vee \\ \vee \left(\mu_{ct}(g_1) \wedge \mu_{\text{compl}}(g_2) \wedge \mu_{\text{simple}}(g_3)\right);$$

- for term “High”:

$$\mu_{High}(G) = \left(\mu_{art}(g_1) \wedge \mu_{\text{complex}}(g_2) \wedge \mu_{\text{compl}}(g_3)\right) \vee \\ \vee \left(\mu_{ct}(g_1) \wedge \mu_{\text{compl}}(g_2) \wedge \mu_{\text{complex}}(g_3)\right).$$

Table 3. Knowledge base for language variable *R.*

Number of corrections and colour tests *(r1)*	Editing *(r2)*	Text information *(r3)*	Quality of technical design *(R)*
A little	Literary	Large	Low
A little	Literary	Medium	
Medium	Artistic	Large	Medium
Medium	Literary	Medium	
Large	Technical	Medium	High
Large	Artistic	A little	

Linguistic equations for determine the values of the membership functions for *R* variable:

- for term “Low”:

$$\mu_{Low}(R) = \left(\mu_{little}(r_1) \wedge \mu_{\text{literary}}(r_2) \wedge \mu_{\text{large}}(r_3)\right) \vee \\ \vee \left(\mu_{little}(r_1) \wedge \mu_{literary}(r_2) \wedge \mu_{\text{medium}}(r_3)\right);$$

- for term “Medium”:

$$\mu_{Med}(R) = \left(\mu_{medium}(r_1) \wedge \mu_{\text{artistic}}(r_2) \wedge \mu_{\text{large}}(r_3)\right) \vee \\ \vee \left(\mu_{medium}(r_1) \wedge \mu_{\text{literary}}(r_2) \wedge \mu_{\text{medium}}(r_3)\right);$$

- for term “High”:

$$\mu_{High}(R) = \left(\mu_{large}(r_1) \wedge \mu_{\text{technical}}(r_2) \wedge \mu_{\text{medium}}(r_3)\right) \vee \\ \vee \left(\mu_{large}(r_1) \wedge \mu_{\text{artistic}}(r_2) \wedge \mu_{\text{little}}(r_3)\right).$$

At the next step, we form the fuzzy sets of the linguistic variable *H* "quality of art and technical design" with appropriate membership functions for the terms "low", "medium" and "high" in accordance with the following equation:

$$H(G,R)=\left\{\frac{\mu_{Low}(H)}{\ell_1},\frac{\mu_{Med}(H)}{\ell_2},\frac{\mu_{High}(H)}{\ell_3}\right\} \quad (1)$$

where ℓ_1,ℓ_2,ℓ_3 are the quantitative values of the H linguistic variable relative to the appropriate terms.

4 Implementation of Defuzzification Process

Defuzzification process is performed based on hereinbefore described expert knowledge base, knowledge base of the linguistic variables and fuzzy set (1). Table 4 contains normalized values of the membership functions in three points of the universal set *A* for all linguistic variables.

Table 4. Membership functions of term-sets

Membership functions of term-set $U(g_1)$ (Graphical illustration methods)				Membership functions of term-set $U(r_1)$ (Number of corrections and colour tests)			
a_i, y.o	1	5	9	a_i, y.o.	1	5	9
$\mu_{l\_art}(a_i)$	1	0,77	0,11	$\mu_{little}(a_i)$	1	0,77	0,11
$\mu_{ct}(a_i)$	0,11	1	0,11	$\mu_{medium}(a_i)$	0,11	1	0,11
$\mu_{art}(a_i)$	0,11	0,33	1	$\mu_{large}(a_i)$	0,11	0,77	1
Membership functions of term-set $U(g_2)$ (Complexity of the edition structure)				Membership functions of term-set $U(r_2)$ (Editing)			
a_i, y.o	1	5	9	a_i, y.o.	1	2	3
$\mu_{simple}(a_i)$	1	0,77	0,11	$\mu_{literary}(a_i)$	1	0,77	0,11
$\mu_{compl}(a_i)$	0,11	1	0,11	$\mu_{artistic}(a_i)$	0,11	1	0,11
$\mu_{complex}(a_i)$	0,11	0,66	1	$\mu_{technical}(a_i)$	0,11	0,45	1
Membership functions of term-set $U(g_3)$ (Layout of the edition)				Membership functions of term-set $U(r_3)$ (Text information)			
a_i, y.o	1	5	9	a_i, %	10	42,5	95
$\mu_{simple}(a_i)$	1	0,66	0,11	$\mu_{little}(a_i)$	1	0,55	0,11
$\mu_{compl}(a_i)$	0,11	1	0,11	$\mu_{medium}(a_i)$	0,11	1	0,11
$\mu_{complex}(a_i)$	0,11	0,55	1	$\mu_{large}(a_i)$	0,11	0,66	1

Below, we present the fuzzy logic equations which allows us to determine the membership functions quantitative values for linguistic variables *G* "quality of art design" and *R* "quality of technical design" based on the data presented in the table 4.

Calculation of linguistic variable *G* values:

- for term “Low”:

$$\mu_{low}(G) = (0{,}77 \wedge 1 \wedge 0{,}66) \vee (1 \wedge 0{,}77 \wedge 0{,}66) = 0{,}66$$

- for term “Medium”:

$$\mu_{med}(G) = (0{,}77 \wedge 0{,}77 \wedge 0{,}66) \vee (0{,}77 \wedge 0{,}77 \wedge 1) = 0{,}77$$

- for term “High”:

$$\mu_{high}(G) = (0{,}33 \wedge 0{,}66 \wedge 1) \vee (1 \wedge 1 \wedge 0{,}55) = 0{,}55$$

Calculation of linguistic variable *R* values:

- for term “Low”:

$$\mu_{low}(R) = (0{,}77 \wedge 0{,}77 \wedge 0{,}66) \vee (0{,}77 \wedge 0{,}77 \wedge 1) = 0{,}77$$

- for term “Medium”:

$$\mu_{med}(R) = (1 \wedge 1 \wedge 0{,}66) \vee (1 \wedge 0{,}77 \wedge 1) = 0{,}77$$

- for term “High”:

$$\mu_{high}(R) = (0{,}77 \wedge 0{,}45 \wedge 1) \vee (0{,}77 \wedge 1 \wedge 0{,}55) = 0{,}55$$

At the next step, we calculate the values of the membership functions for linguistic variable *H* "quality of art and technical design" considering the obtained membership functions values for the variables *G* and *R*, which were calculated before:

- for term “Low”:

$$\mu_{low}(H) = (0{,}66 \wedge 0{,}77) \vee (0{,}66 \wedge 0{,}77) = 0{,}66$$

- for term “Medium”:

$$\mu_{med}(H) = (0{,}77 \wedge 0{,}77) \vee (0{,}77 \wedge 0{,}77) = 0{,}77$$

- for term “High”:

$$\mu_{high}(H) = (0{,}55 \wedge 0{,}77) \vee (0{,}55 \wedge 0{,}55) = 0{,}55$$

Finally, we perform the defuzzification of the fuzzy set (1) using center mass technique. The result of this step implementation is determination of quantitative value of the quality index of book editions prepress preparing:

$$H = \frac{\sum_{i=1}^{m} \left[\underline{H} + (i-1) \frac{\overline{H} - \underline{H}}{m-1} \right] \mu_i(H)}{\sum_{i=1}^{m} \mu_i(H)} \qquad (2)$$

where $\underline{H}, \overline{H}$ are the minimum and the maximum values of the linguistic variable H "quality of art and technical design" respectively; m is the number of linguistic terms.

Let, variables in the formula (2) take the following values: m = 3; $\mu_1(H) = \mu_{low}(H)$, $\mu_2(H) = \mu_{med}(H)$, $\mu_3(H) = \mu_{high}(H)$; lower and upper bounds for linguistic variable H are follows: $\underline{H} = 10\%$, $\overline{H} = 100\%$. The calculation is carried out in three points of the range: 10, 55, 100. In this case, the value the quality level of art and technical design of the books is calculated as follows:

$$H = \frac{10 \cdot 0{,}66 + 55 \cdot 0{,}77 + 100 \cdot 0{,}55}{0{,}66 + 0{,}77 + 0{,}55} = 52{,}5\% \quad (3)$$

Hereinbefore presented results of the research have allowed us to propose the information technology of forming the quality of art and technical design of the book editions.

5 Structural and Functional Model of Information Technology of Forming the Quality of Art and Technical Design of Books

Fig. 2 presents the structure block-chart of the information technology of forming the quality of art and technical design of the book editions. Its implementation assumes the following stages:

Stage 1. Forming the classification model of prepress preparing of the book editions.

1.1. Formation of general principles of the publishing process and the importance levels of its components.

1.2. Describing the processes of prepress preparation of the books as a component of the research subject.

1.3. Classification and formation of processes, procedures and factors of influence to the stage of the book editions prepress preparing with the use of Delphi's expert method.

1.4. Creating the classification model of prepress preparing the book editions.

Stage 2. Creating a model of priority influence of factors to the quality of art and technical design of the book editions.

2.1. Formation of semantic network of influence of the factors to the quality of art and technical design of the book editions with the use of the logic of predicates. Creation of hierarchical trees of linkages between factors taking into account the influence of both types: direct and indirect ones.

2.2. Estimation of factor weights (based on the semantic network) by ranking method. This step allows us to determine the hidden relationships between the factors. Creation of a multilevel model of weight values of the factors of quality of art and technical design of the book editions.

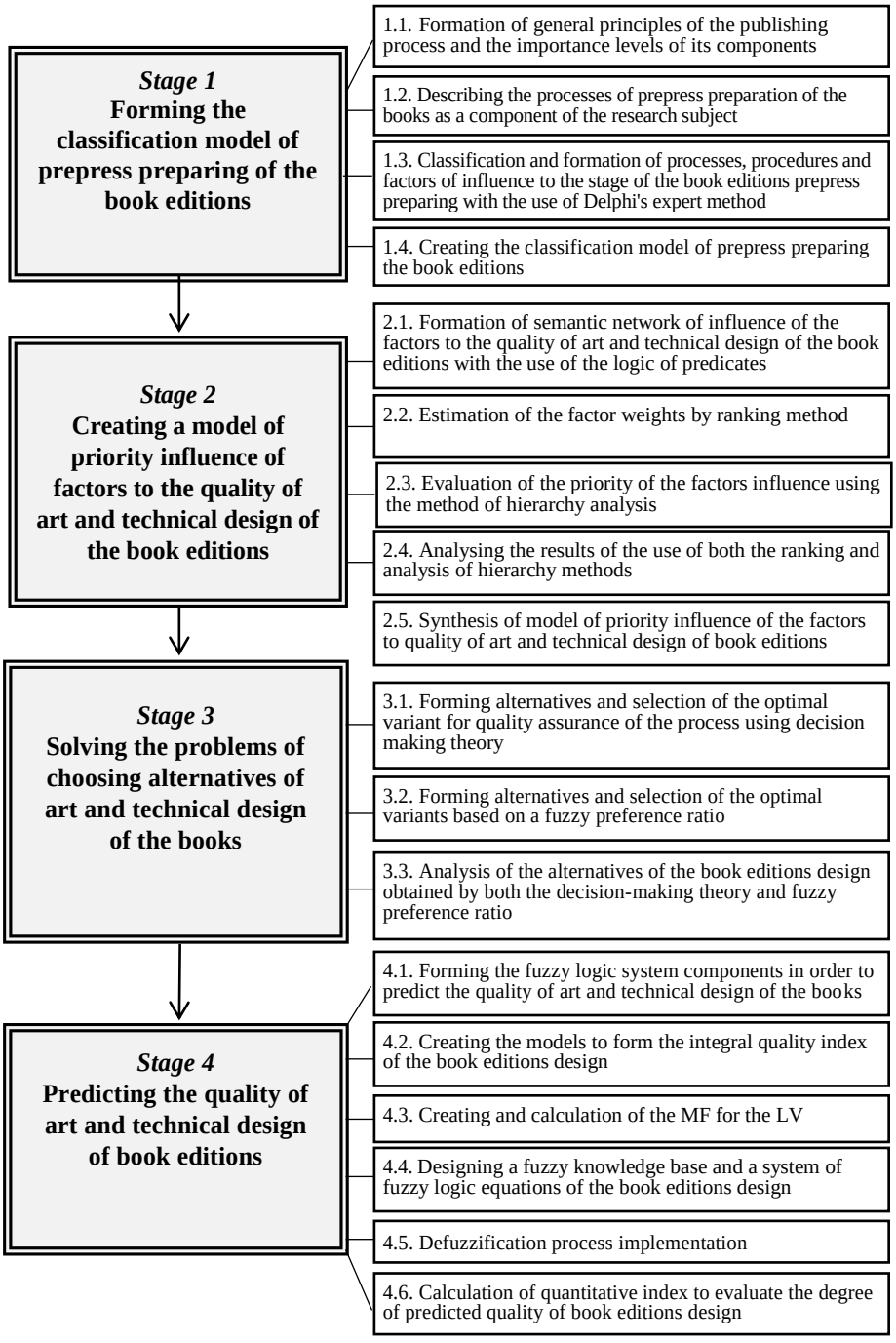

Fig. 2. Structural and functional model of information technology of forming the quality of art and technical design of book editions

2.3. Evaluation of the priority of the factors influence (based on the semantic network of factors) using the method of hierarchy analysis by creation of a binary dependences matrix and a reachability matrix between the factors. Implementation of an iterative algorithm for the formation of importance levels using the reachability matrix. Creation of the iterative tables for purpose of formation of the factor levels. Creation of a model of priority influence of the factors to the studied process quality.

2.4. Analysing the results of the use of both the ranking and analysis of hierarchy methods and determination of the priority for the best method.

2.5. Synthesis of model of priority influence of the factors to quality of art and technical design of book editions. Creation of a matrix of pairwise comparisons by comparison analysis of the factors based on the scale of the relative importance of the objects. Processing the matrix and obtaining specified weighted values of the factors - the basis of an optimized multilevel model of ensuring the quality of the books design.

Stage 3. Solving the problems of choosing alternatives of art and technical design of the books.

3.1. Forming alternatives and selection of the optimal variant for quality assurance of the process using decision making theory. Solving the problem of multicriterial optimization for the mutually undominant factors which make up the Pareto set. Evaluating the alternatives using importance degree of the selected factors. Creating a matrix of pairwise comparisons for factors of Pareto set, normalizing the components of its main vector. Determination of the utility function maximum value.

3.2. Forming alternative variants of art and technical design of book editions considering the factors-linguistic variables of the Pareto set on the basis of fuzzy relations of their advantages in the alternatives and calculated values of the convolutions membership functions. Determination of the optimal variant based on the alternative selection algorithm in the following sequence: establishing a preference ratio for each of the factors relative to the set of the alternatives; creation of the relations matrix; creation of the relationships convolution; determination of the undominant alternatives set; calculation of the convolution membership function values for appropriate alternatives; finding the convolution intersection and appropriate membership function.

3.3. Analysis of the alternatives of the book editions design obtained by both the decision-making theory and fuzzy preference ratio.

Stage 4. Predicting the quality of art and technical design of book editions.

4.1. Forming the fuzzy logic system components in order to predict the quality of art and technical design of the book editions.

4.2. Creating the models to form the integral quality index. Setting the term sets of values for the linguistic variables with corresponding values variation ranges.

4.3. Creating and calculation of the linguistic variables membership functions. Determination of the membership functions quantitative values for the used terms.

4.4. Designing a fuzzy knowledge base and a system of fuzzy logic equations of the book editions design. Creation of the knowledge matrices for the appropriate

linguistic variables. Formation of the fuzzy logic equations. Determination of the membership functions values for the set of terms.

4.5. Defuzzification process implementation. Formation of the normalized values of membership functions in the points of division of the universal set for all linguistic variables. Calculation of fuzzy logical equations for appropriate terms.

4.6. Calculation of quantitative index to evaluate the degree of predicted quality of book editions design.

6 Conclusions

This paper reflects the result of the research concerning the formation of the quality of art and technical design of book editions. At the first step, we have created the classification model of prepress preparing book editions. Then, we carried out based on this model formalized mapping and description of relationships between factors using semantic networks and predicate logic, which allowing us further research with the use of both the hierarchy theory and fuzzy logic. Multilevel models of priority influence of separated factors to the quality of art and technical design of book editions based on the calculation and ordering of their weight values by the method of hierarchies ranking and analysis were synthesized and optimized. This fact has allowed us to design alternatives and calculations of optimal variants of the book editions process preparing. As the result of the research, we have proposed a multilevel hierarchical model which contains the algorithm of forming the quality of art and technical design of the book editions.

The decision concerning evaluation of the quality of art and technical design of the book editions was taken based on fuzzy logic theory. Implementation of this technique assumes design of the fuzzy knowledge base which allows us to form relationships between physically separated quantitative variables during the process of art and technical design of book editions. The fuzzy knowledge matrices for the corresponding linguistic variables are designed during the simulation process. The systems of fuzzy logical equations that determine the procedures of obtaining the weights of the membership functions for the set of linguistic terms of the integral quality index of the investigated process quality have been development and calculated.

Defuzzification process was performed based on the normalized values of the membership functions in three points of division of the universal set A for all linguistic variables. The numeric value H = 52,5% of quality of the art and technical design of the book edition was obtained as the simulation result. The maximum value of this index was 100%. The conducted research allows us to obtain the predicted value of the quality index of the process of art and technical design of a book edition at the initial stage of its design.

References

1. Senkivskyy, V.M., Osinchuk, O.I.: Classification of factors prepress processes. Scientific Papers, 1(54), 60-67 (2017)
2. Zadeh, L.: Fuzzy logic = computing with words. IEEE Transactions on Fuzzy Systems 4(2), 103-111 (1996), http://ieeexplore.ieee.org/document/493904/
3. Jana, D.K., Roy, K., Dey, S.: Comparative assessment on lead removal using micellar-enhanced ultrafiltration (MEUF) based on a type-2 fuzzy logic and response surface methodology. Separation and Purification Technology, 207, 28-41 (2018) doi: 10.1016/j.seppur.2018.06.028
4. Ponce, P., Molina, A., Grammatikou, D., Mata, O.: Fuzzy logic type 1 and 2 for social robots and apps for children with autism. Proceedings of a Special Session - 16th Mexican International Conference on Artificial Intelligence: Advances in Artificial Intelligence, MICAI 2017, art. no. 8575558, 1-8 (2018) doi: 10.1109/MICAI-2017.2017.00009
5. Gong, G., Chen, J.C.: Develop fuzzy logic inference system to predict carbon fiber-reinforced polypropylene hybrid composite's shrinkage. International Journal of Plastics Technology, 22 (2), pp. 262-274 (2018) doi: 10.1007/s12588-018-9223-x
6. Tkachenko, R., Izonin, I., Kryvinska, N., Chopyak, V., Lotoshynska, N., Danylyuk, D.: Piecewise-linear approach for medical insurance costs prediction using SGTM neural-like structure. CEUR Workshop Proceedings, 2255, 170-179 (2018)
7. Babichev, S. An evaluation of the information technology of gene expression profiles processing stability for different levels of noise components. Data, 3 (4), art. no. 48 (2018) doi: 10.3390/data3040048
8. Jabłoński, K., Grychowski, T.: Fuzzy inference system for the assessment of indoor environmental quality in a room. Indoor and Built Environment, 27(10), 1415-1430 (2018) doi: 10.1177/1420326X17728097
9. Veerasamy, V., Abdul Wahab, N.I., Ramachandran, R., Mansoor, M., Thirumeni, M., Othman, M.L.: High impedance fault detection in medium voltage distribution network using discrete wavelet transform and adaptive neuro-fuzzy inference system. Energies, 11 (12), art. no. 3330 (2018) doi: 10.3390/en11123330
10. Kanishcheva, O., Vysotska, V., Chyrun, L., Gozhyj, A.: Method of integration and content management of the information resources network. Advances in Intelligent Systems and Computing, 689, pp. 204-216 (2018) doi: 10.1007/978-3-319-70581-1_14
11. Naum, O., Chyrun, L., Vysotska, V., Kanishcheva, O.: Intellectual system design for content formation. Proceedings of the 12th International Scientific and Technical Conference on Computer Sciences and Information Technologies, CSIT 2017, 1, art. no. 8098753, pp. 131-138 (2017) doi: 10.1109/STC-CSIT.2017.8098753
12. Xi, C., Dong, J.: Adaptive fuzzy guaranteed performance control for uncertain nonlinear systems with event-triggered input. Applied Mathematics and Computation, 363, art. no. 124604 (2019) doi: 10.1016/j.amc.2019.124604
13. Ghasemalipour, S., Fathi-Vajargah, B.: Fuzzy simulation of European option pricing using mixed fractional Brownian motion. Soft Computing, 23 (24), pp. 13205-13213 (2019) doi: 10.1007/s00500-019-03862-2
14. Mohammadikia, R., Aliasghary, M.: Design of an interval type-2 fractional order fuzzy controller for a tractor active suspension system. Computers and Electronics in Agriculture, 167, art. no. 105049 (2019) doi: 10.1016/j.compag.2019.105049
15. D'Urso, P., Massari, R.: Fuzzy clustering of mixed data. Information Sciences, 505, pp. 513-534 (2019) doi: 10.1016/j.ins.2019.07.100

16. Divandari, M., Rezaie, B., Ranjbar Noei, A.: Speed control of switched reluctance motor via fuzzy fast terminal sliding-mode control. Computers and Electrical Engineering, 80, art. no. 106472 (2019) doi: 10.1016/j.compeleceng.2019.106472
17. Karthick Raghunath, K.M., Thirukumaran, S.: Fuzzy-based fault-tolerant and instant synchronization routing technique in wireless sensor network for rapid transit system. Automatika, 60 (5), pp. 547-554 (2019) doi: 10.1080/00051144.2019.1643963
18. Senkivskyy, V. M., Pikh, I. V., Holubnyk, T. S.: Unclear base of knowledge and unclear logical equalizations in the process of realization of assembling lowering. Scientific Papers, 3(48), 111-119 (2014)
19. Holubnyk, T.S., Senkivskyy, V.M., Pikh, I.V.: Principles of fuzzy logic are at providing of quality forming of assembling lowering. Scientific Papers, 1–2 (46-47), 77-83 (2014)
20. Durniak, B.V., Pikh, I.V., Senkivskyy, V.M.: Formation of the edition design process quality on the basis of matrices of knowledge and fuzzy logic equations. Printing and Publishing, 1, 11–18 (2017)
21. Havenko, S. F., Senkivskyy, V. M., Senkivska, N. Y.: Integral prognosis of quality of book editions. Scientific Papers, 1, 144–148 (2012)
22. Pikh, I.V., Senkivskyy, V.M., Senkivska, N.Y., Kalynii, I. V.: Theoretical basis of quality assurance of publishing and printing processes (Part 4. Forecasting and quality assurance by means of fuzzy logic). Scientific Papers, 1(54), 22-30 (2017)
23. Shtovba, S.D., Pankevych, O.D.: Fuzzy Technology-Based Cause Detection of Structural Cracks of Stone Buildings. 2018 CEUR Workshop Proceedings, 2105, 209-218 (2018)
24. Osinchuk, O.I., Lytovchenko, O.V., Kalynii, I.V.: Formation of integral indicators of the planning quality and art and technical design of books by means of fuzzy set theory. Modelling and Information Technology, 85, 137-142 (2018)