Modeling of Alternatives and Defining the Best Options for Websites Design

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Abstract
Electronic media resources, including websites which occupy a leading niche, have a much shorter history than printed equivalents of means of communication between users. However, their focus on computers, electronic devices and software, and, in particular, the Internet has caused a rapid development of the technical and software component of this industry on one hand, and a rapid growth of active users, reaching several billion on the other hand. Global and relatively short-time distribution of sites, as well the subjective preferences of their developers, generates significant problems of a high-quality nature. Considering the above mentioned, the presented article has revealed the essence of the information approach to the development of the alternatives and finding the optimal options for high-quality website design, implemented on the basis of considering the prevailing influence of Pareto set factors. The theoretical basis of the research was the method of hierarchies' analysis, multi-attribute utility theory and multi-objective optimization.

Keywords
Website, modeling, factors, Pareto set, alternative, multi-objective optimization, function, convolution of relations.

1. Introduction

The problem of the quality of printing products and processes related to its manufacture has not lost its relevance during the centuries of existence of the printed word – one of the main means of readers communication [1]. Theoretical and applied achievements in the field of publishing and printing demand a continuous upgrading of products, while a constant competition in the sales market determines further steps to improve it [2-4]. Computerization of the printing process caused its significant progress on one hand, and became the reason for finding the best ways of producing information (on the point of time, cost and efficiency) and conveying it to the users on the other hand [5-7]. The result was the emergence of electronic devices of communication, which, enhanced by the appearance of the Internet, carried out a revolutionary coup in the field of exchange of world online information and global communication without borders.

The websites have become one of the most effective and most commonly used tools to store the data compiled page by page (like in a printed book), accessed through the homepage (similar to the content in a printed edition) using a browser, such as Internet Explorer, Edge, or Chrome via a website URL (similar to a book title). This comparison with the traditional book is interesting in the

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point that the electronic information content is developed by the application of universal methodology of hierarchical data structuring [8-10], which makes it possible to use a wide range of theoretical researches obtained in the course of publishing and printing processes design and focused on printed (paper) products [11-13].

Despite the large number of existing websites (there are up to two billion of websites in the Internet), researchers distinguish a little more than two dozen of their types or categories [15,16]. These include web archives, corporate, gaming, government, reference, news, personal websites, social networks, etc. This classification becomes a prerequisite for distinguishing the quality characteristic of the vast majority of web resources from the general set of factors and allows to define some generalized subset of determining factors which serves the initial research base to measure the degree and priority of their influence on the development of alternatives and defining the best options of the design process. Thus, a logical addition to existing software systems and technical devices ensuring the quality of websites could be a theoretically balanced information component that will confirm the relationship between the factors of the website development process and the degree of their prognostic impact on obtaining a prognostically high-quality product.

2. Formal problematic statements

The quality of electronic web resources depends not only on the priorities of the identified factors, but also on the modes (options) selected for the implementation of electronic resources design processes. Their efficiency is certainly determined by conditional numerical expression of factors influence (if any) on the alternative efficiency [19, 20] or fuzzy ratios of advantages in the projected variations at the absence of numerical expression of the factor’s "participation" in the process of websites development [15, 18]. Of course, the initial stage of solving the problem of alternatives development and determining the optimal one is to distinguish from the general set the factors that dominate the others by their influence, that is, factors with lower weight priorities are removed from further consideration. The limitation of the number of factors is justified by the use of the Pareto principle [7, 14], its application simplifies the process of alternatives development and ensures sufficient quality of the result for practical use.

For the first case, the problem of multi-sectoral optimization on a set of alternatives D in the presence of target functions $f(x)=(f_1(x),...,f_m(x))$ is to form utility functions, calculate their values and set the maximum value, that is, $f_i(x)\to\max_{x\in D},\ i=\overline{1,m}$ [7, 14]. Multi-criterial choice of alternative is based on the method of linear convolution of criteria [16], based on linear combination of partial functionals $f_1,...,f_m$ into one generalized target functionality

$$F(w,x)=\sum_{i=1}^{m} w_i f_i(x)\to\max_{x\in D};\quad w\in W\ , \tag{1}$$

where $W=\left\{w=(w_1,...,w_m)^T;\ w_i>0;\ \sum_{i=1}^{m} w_i=1\right\}$.

The value of utility functions is equated with the corresponding weights w_i of factors involved in the development of optimal alternatives, which is determined on the basis of the theorem of the method of multi-criterial theory of utility [7, 19]: for criteria (in our case, factors) conditionally independent by their usefulness and advantage there is a function of utility

$$U(x)=\sum_{i=1}^{m} w_i u_i(y_i)\,, \tag{2}$$

which serves as a criterion for choosing the best option. At the same time $U(x)$ – multi-criterial utility function $(0\le U(x)\le 1)$ of the x alternative; $u_i(y_i)$ is a utility function of the i factor; $(0\le u_i(y_i)\le 1)$; y_i is the value of the x alternative by i factor; w_i is weight of the i factor, where $0<w_i<1,\ \sum_{i=1}^{m} w_i=1$

The practical implementation of the method regarding the website design process will be given in the appropriate section below.

To complete and confirm the reliability of the research, we will use another method for calculating the optimal design option for the electronic resource, which is used in the absence of a numerical expression of "participation" of factors in the development of alternatives. In this case, the multi-objective optimization method [7, 20-21] is preferred, according to which fuzzy relations of paired preferences between alternatives are used for decision-making, their degree of availability can be set by a number on a segment [0;1]. Let us give a brief essence of the method [7, 14].

For a couple of alternatives (x, y) relations of unrestrained advantage F means that x is not worse than y, it means that $x \geq y$; similarly, if y is not worse than , x, then$(y \geq x)$; on the condition that x and y are not comparable it follows that $(x, y) \notin F$ та $(y, x) \notin F$. It is claimed that for strict utility functions, f_j the alternative x with a higher score $f_j(x)$ prevails by j factor in the y alternative, which has a lower rate $f_j(y)$ and this advantage of F_j is described by a clear ratio:

$$F_j = \{(x, y) : f_j(x) \geq f_j(y), x, y \in X\}. \quad (3)$$

Finally, on the X set we choose an alternative, having the highest rate of the utility function, when considering the factors involved in the process:

$$f_j(x_0) \geq f_j(y), \ \forall j = 1, m; \ \forall y \in X. \quad (4)$$

As a result, the Pareto-optimal alternative is defined, helping to make a theoretically justified decision concerning the fuzzy relations of advantages between factors which allow to obtain an electronic resource of a proper quality.

3. Literary review

The hierarchical design of websites whose URLs indicate the site name and functional purpose has been noted above; the content is arranged page by page with an address entrance through the main page using a browser. The architecture and access to the electronic data storage are somewhat similar to the technology of hierarchical data structuring tested by the practice and method of printed products use. It suggests the possibility and feasibility of application of theoretical basis developed in the course of research of printed editions technology and quality design, to the processes of electronic resources development.

Considering the above-mentioned the research works concerning the information aspect of the development and predictive assessment of the quality of printing products occupy a significant place in the list of used sources. The initial stages of this process are related to the information technologies for the development quality and artistic and technical design of the books [1, 2], methodological developments in solving the problem of forecasting and ensuring the quality of publishing and printing processes [6]. An important component concerns the research of the process of printed books reproduction; this research methodology after certain modifications may be suitable for the distribution of electronic editions [3-5]. In-depth analysis and significant results have been represented in a fundamental monograph [7], describing the methods and means of processing and synthesis of factors models having influence on the quality of book products, modeling alternative design options for book editions. A great interest has been caused by works directly or indirectly related to the topics of this article. Theoretical basis for ensuring the quality of publishing and printing processes has been developed concerning the design of alternative implementation options [8], a multi-criterial choice of alternative variants of compositional design of the edition on the basis of linear convolution of criteria [9] and the development of alternatives based on fuzzy advantages ratios [10]. Alternative editions, including the quality of artistic, technical and compositional design of editions [8, 11, 12] and the printing process have been offered in the works [13, 14].

The fundamental points underlying the technologies of website development and usage contain the history of development, prevalence rating, software, basic principles of additive web design, which enables practical display of information, convenient navigation, compatibility and possibility to work on the whole range of devices, have been offered in [15, 16]. The list of extended sets of factors related to site quality indicators and step-by-step technology for developers can be obtained in [17, 18].

A brief overview of literary sources indicates the absence of a theoretically balanced methodological approach to the problem of website quality development. At the same time, the essence of scientific novelty and practical value of the solutions recommended in the article consists in the use of methods and means of the theory of research of operations, modeling theory, as the basis of formalized expression of the degree of impact of certain factors on the quality of website design through the development of alternative and defiining the optimal options for the implementation of the processes.

4. Goals of the article (problem setting)

To highlight factors attributed to the Pareto set, having a prevailing impact on the website development process. To calculate the usefulness of alternatives by measuring the importance in variants. To find the optimal option for the implementation of the process at the maximum value of utility functions of the combined target functionals, obtained on the basis of the method of linear convolution of criteria. To confirm the reliability of the obtained result using the multi-objective optimization method. To build the matrices and convolution of relations, to calculate the functions of convolutions affiliation. The maximum value of the affiliation of sets intersection function of undominated alternatives determines the best option.

5. Materials and Methods

We will carry out the research of the website design process separately, using sequentially both of the above-mentioned methods and the generalized set of factors distinguished by us, without emphasizing their semantic value.

5.1. Alternatives modeling by method of linear convolution of criteria

Let the Pareto set be expressed by the factors F_1, F_2, F_3, F_4. We give three alternative options for the implementation of the design process, marking them 1, 2, 3. Taking into account the formula (2) we will have the following parameters for calculations: $m = 4$; $u_i(y_i) = u_{ij}$ that is utility of j alternative $(j = 1,2,3)$ by i factor $(i = 1,...,4)$. Finally, the expression for calculating the values of utility functions will look like this:

$$U_j = \sum_{i=1}^{4} w_i u_{ij}; \ j = 1,2,3, \tag{5}$$

where U_j is a multi-factor assessment of utility of j alternative. The assessment of the alternatives by formally expressed measures of importance of the selected factors will be reflected in Table1.

Table 1

Assessment of the alternatives by factors of Pareto set

Factors	Factors weights	Assessment of factors share in alternative variants		
		1	2	3
F_1	w_{F1}	p_{11}	p_{12}	p_{13}
F_2	w_{F2}	p_{21}	p_{22}	p_{23}
F_3	w_{F3}	p_{31}	p_{32}	p_{33}
F_4	w_{F4}	p_{41}	p_{42}	p_{43}

Table 1 introduced the following symbols: w_{Fi} is a starting (initial) weight of the i factor; p_{ij} is a measure of assessment as a percentage of the importance of i factor in relation to the j alternative. It should be noted that the following condition has been adopted $\sum_{i=1}^{4} p_{ij} = 100;\ j = 1,2,3$ to evaluate the options.

Factors specified in Table 1 are considered the starting set with the initial weight values. For further research, according to the second column and the Saati Comparative Scale [7] we build a matrix of paired comparisons in the Table 2; after its processing we get the refined values of the Pareto set factors w_i, suitable for calculating utility functions by the formula (5).

Table 2
Matrix of Paired Comparisons of Pareto Set Factors

Factors	F_1	F_2	F_3	F_4
F_1	1	w_{F1}/w_{F2}	w_{F1}/w_{F3}	w_{F1}/w_{F4}
F_2	w_{F2}/w_{F1}	1	w_{F2}/w_{F3}	w_{F2}/w_{F4}
F_3	w_{F3}/w_{F1}	w_{F3}/w_{F2}	1	w_{F3}/w_{F4}
F_4	w_{F4}/w_{F1}	w_{F4}/w_{F2}	w_{F4}/w_{F3}	1

Matrix elements w_{Fi}/w_{Fj} mean the result of comparison of weight values w_{Fi} and w_{Fj}.

As a result of the matrix processing and normalizing the components of its own main vector, we obtain the final weight values of the w_1, w_2, w_3, w_4 factors.

The next step concerns obtaining the values of the utility functions of j alternative by i factor on the basis of paired comparisons matrixes, containing p_{ij} values elements that reflect the advantages of alternatives relative to each of the factors in the rows of Table 1. Finally, we get the value of utility functions for the following factors: F_1 – u_{11}, u_{12}, u_{13}; Z_2 – u_{21}, u_{22}, u_{23}; Z_3 – u_{31}, u_{32}, u_{33}; Z_4 – u_{41}, u_{42}, u_{43}.

The final multi-factor assessment of the usefulness of alternatives for variants 1, 2, 3 can be expressed on the basis of the (3.3) formula by the following ratios:

$$U_1 = w_1 \cdot u_{11} + w_2 \cdot u_{21} + w_3 \cdot u_{31} + w_4 \cdot u_{41};$$
$$U_2 = w_1 \cdot u_{12} + w_2 \cdot u_{22} + w_3 \cdot u_{32} + w_4 \cdot u_{42}; \quad (6)$$
$$U_3 = w_1 \cdot u_{13} + w_2 \cdot u_{23} + w_3 \cdot u_{33} + w_4 \cdot u_{43}.$$

The maximum value of utility functions $U_i\ (i = 1,2,3)$ of the combined partial target functionals determines the best option for the implementation of the website design process.

5.2. Modeling of alternatives by multi-objective optimization method

Since the initial criteria for the multicritical alternative problem are the factors (criteria) of the Pareto set (the edition design process), it is necessary to convolve many criteria into one scalar. To do this, we use the method of intersection, the essence of which is as follows [7, 14].

Let's note $Z_1 = \bigcap_{j=1}^{m} F_j$. It is claimed that a set of alternatives with an advantage ratio Z_1 corresponds to a set of alternatives with utility functions $f_j(x)$. This means that we replace a set of relations F_j ($j = \overline{1,m}$) with an intersection and find undominated alternatives for a fuzzy advantage ratio Z_1. If $\mu_j(x,y)$ is the function of affiliation to a fuzzy advantage ratio F_j, then

$$\mu_j(x,y)=\begin{cases}1,\ if\ f_j(x)\geq f_j(y),\ it\ means(x,y)\in F_j;\\ 0,\ if\ (x,y)\notin F.\end{cases} \quad (7)$$

Considering (7) the function of affiliation (convolution of criteria) for a fuzzy advantage ratio Z_1 will look like this:

$$\mu_{Z_1}(x,y)=\min\{\mu_1(x,y),\mu_2(x,y),...,\mu_m(x,y)\}. \quad (8)$$

Convolution of criteria (8) can be expressed due to the weight factors w_j and related utility functions as follows:

$$R(x)=\min_j w_j f_j(x). \quad (9)$$

Similarly, one more type of relations convolution $\{F_j\}$ is introduced, which uses the weights and utility functions of factors:

$$Z_2=\sum_{j=1}^{m} w_j f_j(x),\ \partial e\ \sum_{j=1}^{m} w_j=1,\ w_j\geq 0. \quad (10)$$

Convolution of relations Z_2 corresponds to the function of affiliation $\mu_{Z_2}(x,y)=\sum_{j=1}^{m} w_j\mu_j(x,y)$.

6. Experiment

For further research by the above-mentioned methods we will distinguish the factors of Pareto subset from some generalized set [16-18]. Also, in addition to the semantic name, we assign them the conditional weights defined by the experts on the column scale, which determine among the general set the priorities of the dominating factors regarding the impact on the process of website quality development. So, for further processing we form a set $F=\{F_1,F_2,F_3,F_4\}$, where: F_1 (100) is site content (text, illustrations, diagrams, tables, etc.); F_2 (70) is usability (design, interface); F_3 (50) is information security (protection from unauthorized access); F_4 (40) – performance (response time for user commands).

According to the logic of the method of linear convolution of criteria, we build table 3 to evaluate the alternatives by factors, keeping their weight values mentioned above. Simultaneously, we arrange combinations of assessment of the factors share in the alternatives.

Table 3

Experimental variant of assessment of alternatives by factors

Factors	Factors wieghts	Evaluation of the factors share in alternatives in %		
		1	2	3
Website content (F_1)	100 (w_{F1})	20	10	70
Usability (F_2)	70 (w_{F2})	50	30	20
Informationsecurity (F_3)	50 (w_{F3})	20	50	30
Performance (F_4)	40 (w_{F4})	20	40	40

The total set of factors is more complete compared to the Pareto subset, so it is advisable to consider them as an autonomous set and calculate the specified weight values for them. To do this, according to the initial weights of the factors of Table 3, a matrix of paired comparisons is built, which is then processed by the program "Simulation modeling in system analysis by binary comparisons" [22]. It provides us with the refined normalized weight values of the Pareto set factors: $w_1=0{,}5;\ w_2=0{,}3;\ w_3=0{,}1;\ w_4=0{,}1$.

The criteria for the reliability of calculations are within the permissible limits, namely: the maximum actual value of the matrix is $\lambda_{\max} = 4{,}1$; consistency index is $IU = 0{,}06$; consistency ratio is $WU = 0{,}07$. New weight values will be used for calculating the utility functions of factors.

Experimental determination of the optimal variant of site quality development by multi-objective optimization method can be performed trough the step by step implementation of the following algorithm [14].

Step 1: We establish a set of alternatives $X\{x_1, x_2, x_3\}$. For each of the factors of the Pareto set, we establish fuzzy advantages ratios between variants that will be identified by the mnemonic names of factors F_j, $j = 1,2,3,4$.

Step 2. The ratio F_j will correspond to the weight values of w_j factors and their corresponding functions of affiliation $\mu_j(x, y)$, calculated according to the rule (7). We find a convolution of fuzzy relations of advantages between variants $Z_1 = \bigcap_{j=1}^{4} F_j$.

Step 3: In the $\{X, Z_1\}$ set we establish a set of undominated alternatives Z_1^{ud} with affiliation functions

$$\mu_{Z_1}^{ud}(x) = 1 - \sup_{y \in X} \left\{ \sum_{j=1}^{4} \mu_{Z_1}(y, x) - \mu_{Z_1}(x, y) \right\}. \tag{11}$$

Step 4: Based on the expression (10) for the convolution Z_2 we find an additive convolution of fuzzy relations with functions of affiliation

$$\mu_{Z_2}(x, y) = \sum_{j=1}^{4} w_j \mu_j(x, y),\ \sum_{j=1}^{4} w_j = 1,\ w_j \geq 0. \tag{12}$$

Step 5: For convolution Z_2 we determine a set of undominated alternatives:

$$\mu_{Z_2}^{ud}(x) = 1 - \sup_{y \in X} \left\{ \sum_{j=1}^{4} \mu_{Z_2}(y, x) - \mu_{Z_2}(x, y) \right\}. \tag{13}$$

Step 6: We are looking for a common set of undominated alternatives as the intersection of sets Z_1^{nd} and Z_2^{ud}, it means $Z_{ud} = Z_1^{ud} \bigcap Z_2^{ud}$, has an affiliation function

$$\mu_{ud}(x) = \min\left\{ \mu_{Z_1}^{ud}(x), \mu_{Z_2}^{ud}(x) \right\}. \tag{14}$$

The optimal alternative is determined by the maximum value of the affiliation function $\mu_{ud}(x)$.

7. Results

The procedures for obtaining numerical results will be carried out sequentially according to the theoretical principles of both methods involved in the research.

In accordance with the method of linear convolution of criteria, we calculate the value of the utility functions of factors. To do this, we build the paired comparison matrices according to the data of the last three columns of Table 3, which reflect the advantages of alternatives for each of the factors. We will check the consistency of the results using the maximum custom value of the priority vector $\lambda_{\max}$ for each matrix, consistency index IU and consistency ratio WU.

Thus, the matrix of pair comparisons for the "Site Content" factor (F_1) considering the percentage of its effectiveness in the alternatives will look like this (Table 4).

Table 4
Paired comparison matrix for F_1 factor

F_1	1	2	3
1	1	2	1/4
2	1/2	1	1/7
3	4	7	1

After processing the matrix, we have the following values of variant utility functions by factor F_1: $u_{11} = 0{,}186;\ u_{12} = 0{,}097;\ u_{13} = 0{,}715$ with criteria $\lambda_{\max} = 3{,}00;\ IU = 0{,}00;\ WU = 0{,}00$.

Lowering similar matrix of pair comparisons for the rest of the factors, we give the results of their processing.

"Usability" factor (F_2): $u_{21} = 0{,}576;\ u_{22} = 0{,}341;\ u_{23} = 0{,}081$.

Criteria $\lambda_{\max} = 3{,}03; IU = 0{,}01;\ WU = 0{,}03$.

"Information security" factor (F_3): $u_{31} = 0{,}093;\ u_{32} = 0{,}626;\ u_{33} = 0{,}279$.

Criteria: $\lambda_{\max} = 3{,}08; IU = 0{,}04;\ WU = 0{,}07$.

“Performance” factor (F_4): $u_{41} = 0{,}6;\ u_{42} = 0{,}2;\ u_{43} = 0{,}2$.

Criteria $\lambda_{\max} = 3{,}00; IU = 0{,}00;\ WU = 0{,}00$.

According to the obtained functions of the utility and weight priorities of factors, we get the final values of the combined functionals calculated by expressions (6), namely:

$$U_1 = 0.5 \cdot 0.186 + 0.3 \cdot 0.576 + 0.1 \cdot 0.093 + 0.1 \cdot 0.6;$$
$$U_2 = 0.5 \cdot 0.097 + 0.3 \cdot 0.341 + 0.1 \cdot 0.626 + 0.1 \cdot 0.2; \quad (15)$$
$$U_3 = 0.5 \cdot 0.715 + 0.3 \cdot 0.081 + 0.1 \cdot 0.279 + 0.1 \cdot 0.2.$$

As a result, we get: $U_1 = 0.334$; $U_2 = 0.233$; $U_3 = 0.430$.

Thus, among the developed alternatives of the design process with the simultaneous development of website quality, the third option is considered as optimal, because of its maximum functional. At the same time, as follows from the Table 3, the "Site Content" factor has a decisive measure of influence on this result.

Further calculations will be applied to the multi-objective optimization method.

Based on the above-mentioned algorithm we will choose an alternative using the specified method, and find the best option for website design. Let us have a set of alternatives $X\left\{x_1, x_2, x_3\right\}$ according to Step 1.

We leave without changes the factors of the Pareto set, which determine the total relation of the advantages, and the weights obtained earlier by the priority of factors influence on the website development, namely: $w_1 = 0{,}5;\ w_2 = 0{,}3;\ w_3 = 0{,}1;\ w_4 = 0{,}1$.

For each of the factors, we will establish fuzzy relations of the advantages between the options.

Website content (F_1): $x_1 > x_2$, $x_1 < x_3$, $x_2 < x_3$.

Usability (F_2): $x_1 > x_2$, $x_1 > x_3$, $x_2 > x_3$.

Information Security (F_3): $x_1 < x_2$, $x_1 < x_3$, $x_2 > x_3$.

Performance (F_4): $x_1 > x_2$, $x_1 > x_3$, $x_2 = x_3$.

According to the above-mentioned relations in accordance with the condition (7), we build the matrix of relations F_1-F_4, which simultaneously determine the functions of affiliation to the advantages of alternatives by factors (Table 5-8).

Table 5
Relations matrix of the advantages of alternatives by F_1 factor

	x_i / x_j	x_1	x_2	x_3
$\mu_{F_1}(x_i, x_j)$	x_1	1	1	0
	x_2	0	1	0
	x_3	1	1	1

We build the similar relations matrices for the rest of the factors.

Table 6
Relations matrix of the advantages of alternatives by F_2 factor

	x_i / x_j	x_1	x_2	x_3
$\mu_{F_2}(x_i, x_j)$	x_1	1	1	1
	x_2	0	1	1
	x_3	0	0	1

Table 7
Relations matrix of the advantages of alternatives by F_3 factor

	x_i / x_j	x_1	x_2	x_3
$\mu_{F_3}(x_i, x_j)$	x_1	1	0	0
	x_2	1	1	1
	x_3	1	0	1

Table8
Relations matrix of the advantages of alternatives by F_4 factor

	x_i / x_j	x_1	x_2	x_3
$\mu_{F_4}(x_i, x_j)$	x_1	1	1	1
	x_2	0	1	1
	x_3	0	1	1

In accordance with step 2, we specify a convolution of relations, $Z_1 = F_1 \cap F_2 \cap F_3 \cap F_4$, for which the matrix of values of affiliation functions is entered in table 9.

Table 9
Convolution function values Z_1

	x_i / x_j	x_1	x_2	x_3
$\mu_{Z_1}(x_i, x_j)$	x_1	1	0	0
	x_2	0	1	0
	x_3	0	0	1

The implementation of step 3 is carried out on the basis of Table 9, according to which Z_1 convolution confirms the weakness of alternatives. A set of convolutional affiliation functions in view of (11) can be written in such a generalized expression:

$$\mu_{Z_1}^{ud}(x) = 1 - \sup_{y \in X} \left\{ \mu_{Z_1}(y, x) - \mu_{Z_1}(x, y) \right\}.$$

For each of the alternatives, we get the value of the affiliation functions:

$$\mu_{Z_1}^{ud}(x_1) = 1 - \sup_{y \in X}\{0-0;0-0\} = 1;$$

$$\mu_{Z_1}^{ud}(x_2) = 1 - \sup_{y \in X}\{0-0;0-0\} = 1;$$

$$\mu_{Z_1}^{ud}(x_3) = 1 - \sup_{y \in X}\{0-0;0-0\} = 1.$$

Generalization of the performed calculations gives the result of step 3: $\mu_{Z_1}^{ud}(x) = [1;1;1]$.

The next algorithm procedure (step 4) is to find a fuzzy advantage ratio Z_2, the so-called additive convolution of relations [7, 14, 21] F_j, $j = \overline{1,4}$, by the formula $Z_2 = \sum_{j=1}^{4} w_j f_j(x)$. The value of the functions of convolution affiliation $\mu_{Z_2}(x_i, x_j) = \sum_{k=1}^{4} w_k \mu_{F_k}(x_i, x_j)$ is obtained using the following calculation formulas:

$$\mu_{Z_2}(x_1,x_2) = w_1\mu_{F_1}(x_1,x_2) + w_2\mu_{F_2}(x_1,x_2) + w_3\mu_{F_3}(x_1,x_2) + w_4\mu_{F_4}(x_1,x_2);$$

$$\mu_{Z_2}(x_1,x_3) = w_1\mu_{F_1}(x_1,x_3) + w_2\mu_{F_2}(x_1,x_3) + w_3\mu_{F_3}(x_1,x_3) + w_4\mu_{F_4}(x_1,x_3);$$

$$\mu_{Z_2}(x_2,x_1) = w_1\mu_{F_1}(x_2,x_1) + w_2\mu_{F_2}(x_2,x_1) + w_3\mu_{F_3}(x_2,x_1) + w_4\mu_{F_4}(x_2,x_1);$$

$$\mu_{Z_2}(x_2,x_3) = w_1\mu_{F_1}(x_2,x_3) + w_2\mu_{F_2}(x_2,x_3) + w_3\mu_{F_3}(x_2,x_3) + w_4\mu_{F_4}(x_2,x_3);$$

$$\mu_{Z_2}(x_3,x_1) = w_1\mu_{F_1}(x_3,x_1) + w_2\mu_{F_2}(x_3,x_1) + w_3\mu_{F_3}(x_3,x_1) + w_4\mu_{F_4}(x_3,x_1);$$

$$\mu_{Z_2}(x_3,x_2) = w_1\mu_{F_1}(x_3,x_2) + w_2\mu_{F_2}(x_3,x_2) + w_3\mu_{F_3}(x_3,x_2) + w_4\mu_{F_4}(x_3,x_2).$$

The results of calculations of the values of Z_2 convolutional affiliation functions will be displayed in Table 10.

Table 10

Values of Z_2 convolution function

	x_i / x_j	x_1	x_2	x_3
$\mu_{Z_2}(x_i, x_j)$	x_1	1	0.9	0.4
	x_2	0.1	1	0.5
	x_3	0.6	0.6	1

When calculating convolutions, the value of affiliation functions specified by the relations matrices in tables 5-8 has been used.

For Z_2 convolution we find a set of undominated alternatives (step 5) by the formula (13):

$$\mu_{Z_2}^{ud}(x_1) = 1 - \sup\{(0.1-0.9);(0.6-0.4)\} = 0.8;$$

$$\mu_{Z_2}^{ud}(x_2) = 1 - \sup\{(0.9-0.1);(0.6-0.5)\} = 0.2;$$

$$\mu_{Z_2}^{ud}(x_3) = 1 - \sup\{(0.4-0.6);(0.5-0.6)\} = 1.$$

As a result, we get $\mu_{Z_2}^{ud}(x_i) = [0.8;0.2;1]$.

The last step 6 is to find the convolution of Z_1^{ud} and Z_2^{ud} sets intersection, that is, $Z_{ud} = Z_1^{ud} \cap Z_2^{ud}$, with the relations function

$$\mu_Z^{ud}(x_i) = \min\left\{\mu_{Z_1}^{ud}(x_i), \mu_{Z_2}^{ud}(x_i)\right\}, \quad i = \overline{1,3}. \qquad (16)$$

Considering that $\mu_{Z_1}^{ud}(x_i) = [1;1;1]$, we get $\mu_Z^{ud}(x_i) = [0.8;0.2;1]$.

Z convolution function indicates that the best alternative to the design process of a book edition with the above-mentioned advantages of the utility of factors is x_3 variant as its relations function has the maximum value.

The obtained data confirm the accuracy of the results of investigation, since the best option for designing a book edition calculated above by the method of linear convolution of criteria is also the third option. The expert developers and users of websites have the same opinion which coincides with this theoretically obtained conclusion.

8. Conclusions

The analysis of publications related to the topic of the proposed article has been carried out. The result of the review indicates a lack of theoretical research of the processes of electronic resources design which is an important component of modern media space. The leading thesis for solving this problem is the use of information methodology involving theoretically balanced and successfully applied information technologies and computerized systems, applied tools and simulation models which caused significant progress in the field of printing products quality development.

After investigation of modern technologies applied for the websites development and use we can assume that one of the practically valuable approaches is to distinguish sets of factors that significantly affect the design and development of the quality of electronic resource.

These factors become the information base, which causes their ranking by functional importance and degree of weight due to the priori determination of the website quality. It is important to carry out prognostic evaluation and ensuring the effectiveness of the website development process through the preliminary development of alternative options for the implementation of processes and calculation of the optimal design option according to the established criteria.

The variant of application of the proposed methodology is given in the presented article researching the process of websites design and quality development. As a result, the essence of analytical and algorithmic support suitable for the development of alternatives has been revealed and optimal options fit for the development of electronic product with a valuable content, compositionally complete, protected from unauthorized access and convenient to use have been found.

An important initial condition is the separation of factors of the so-called Pareto set, ordered by the importance of the prevailing influence on the researched process. For theoretical substantiation and effective design of the alternatives, the following methods have been used: a method of analysis of hierarchies, which ensured obtaining of weight priorities of the identified factors through the construction and processing of paired comparisons matrixes; methods of multicriterial theory of utility and multi-objective optimization, offering the mathematical component which served the basis of the research.

The formulas for practical calculation of the values of utility functions and functions of affiliation are given, according to which a decision is made to choose the best option for the implementation of the website design process. Obtaining the same decisions by two methods used to determine the optimal implementation of the website development process indicates the proper reliability of the results.

Since the submitted article is one of the several previously published on similar topics, some of the provisions have been used from other works indicated in the list of references.

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