UDC 004.72+004.032.6

OPTIMIZATION OF MATHEMATICAL MODEL OF THE IMPACT FACTORS HIERARCHY OF THE INTERFACE USE BASED ON MOBILE APPLICATIONS

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In this article, a multilevel model of priority factors (their dependencies)having impact to an experience of mobile applications use has been built on the basis of previously performed evaluations and analysis of factors affecting the process of devices interface use based on mobile applications, by means of pair-wise comparisons method and Saaty scale of relative importance a number row of factors' weights has been set as well the optimization of this model has been done. Comparison of current and previously obtained results has been performed. This model allows establishing of priorities of certain factors relatively to others.

The obtained results confirmed the following conclusions: the developers of devices' interfaces should pay more attention to the systems functionality and correctly put the tasks that need to be addressed under specific actions. Studies have shown, that there is no necessity to pay attention to brands and their animation capabilities, as well as the factors of most users of mobile applications. The results of the optimization will be used for further research on factors that affect the process of using interface devices.

Keywords: *factors, matrix of pair-wise comparisons, Saaty scale, optimization, multilevel model.*

Statement of the problem. Experience is what a person feels when using a product, system or service. The main objects of an investigation are impressions, emotions and benefit obtained from the interaction with the product. As well the experience includes usability, ease of use and system performance. Experience is subjective (associated with the individual feeling and thoughts) and can vary over time with changing circumstances.

Due to the advances in mobility, prevalence and socialization of computer technologies the interaction with computer became part of almost all aspects of human life. This led to a shift from the usual ergonomics design to a much broader and finer design, which would take into account the feelings of users, their motivation and obtained benefits.

The latest research and publications. At the moment Android N is the latest version of the Android operating system. First it came out as a beta version for developers on March 9, 2016 for actual devices of Nexus range (Nexus 6, Nexus 9, Nexus Player, Nexus 5X, Nexus 6P, Pixel C). The final release date for the final version was July 22, 2016 [1].

Innovations in relation to previous versions:

- Android Nougat received an MDI mode of multiple screen division in which the 2 applications can take separate halves of the screen;
- Quick access icons appear on a compact panel;
- Overridden notification, with the possibility of a quick response;
- A background tasks switching: all the background running applications can be quickly displayed by the button «Browse». Double-tap opens the previously launched application and maintenance allows you to choose the right application from all available. This function is used on the Windows operating system with a combination of «Alt + Tab» keys;
- Night mode lets you adjust the brightness to save the battery charge;
- Advanced mode «Doze» helps to save the battery charge when the device is in stable condition;
- New mode «Data Saver» restricts the background use of mobile data;
- New design of folders;
- 72 new emoji;
- Support virtual reality at the hardware level.

iOS 10 was presented on June 13, 2016 at the annual Developers Conference WWDC. iOS 10.0 Beta1 became available the same day for registered developers; release of the stable version is planned for this fall [2].

According to the tests, in a new version of the operating system, performance and uptime of devices were significantly improved.

New features:

- Lock screen: support for widgets and 3D Touch have been added;
- Siri. Access to third party developers has been opened, the context recognition option has been added;
- QuickType. Support for Siri has been added; keyboard language can vary depending on the context;
- Photo. By means of Advanced Computer Vision persons and objects recognition option has been added; automatic creation of «Memories» (albums with grouped pictures or automatically created short video clips) has been added;
- Maps. The interface has been changed considerably, the application has become more «pro-active» and available for third party developers;
- Apple Music. The appearance has been changed, the «Connect» function has been removed, the option of songs' text review has been added;
- News. The interface has been changed, the subscriptions support and news display on the lock screen haves been added;
- HomeKit. New Home application allowing to control the House intelligent systems has been added;
- Phone. Support for VoIP API has been added, functionality is open to third-party developers;
- iMessage. Support for handwriting recognition, many updates and improvements regarding animation messages as well open access to third party developers has been offered.

The purpose of the article is to consider and explore the model of the impact factors hierarchy using interface-based mobile applications with the establishment of numerical weights of derived factors based on pair-wise comparisons and detect predominant action of each factor, which will give the opportunity to explore the presence and consistency in pair-wise comparisons of factors weights and obtain numerical evaluation of the interactions between them in the original graph.

Summary of the basic material. The results of previous research, as well a built model of the factors having impact on the use of mobile applications interface became the basis for the evaluation and optimization of multilevel model factors by means of pair-wise comparisons and Saaty scale of relative importance (table 1) [3].

Table 1

Value of importance	**Factors of comparison**
1	Objects are equivalent
3	One object somewhat predominates the other
5	One object predominates the other
7	One object significantly predominates the other
9	One object absolutely predominates the other
2,4,6,8	Compromise intermediate values

Based on the model of the factors hierarchy having impact on the experience of mobile applications use , a number range of factors weights has been set: Ф (k_5) – 70; З (k_{13}) – 70; Б (k_8) – 60; СГЕ (k_6) – 50; АЕ (k_7) – 50; Н (k_1) – 40; ОЧ (k_{11}) – 30; ФІЗ (k9) – 20; С (k_{10}) – 20; І (k_{12}) – 20; М (k_2) – 10; НАС (k_4) – 10; О (k_3) – 10, which define initial values of levels $V_{вих}$

$$V_{вих}(40; 10; 10; 10; 70; 50; 50; 60; 20; 20; 30; 20; 70).$$

To set the numeric weight factors a pair-wise comparisons matrix has been built, $A = (a_{ij})$, which is inversely symmetric-and meets the relative $a_{ij} = 1/a_{ji}$. When comparing the expert sets, as one factor predominates the other, using a Saaty scale of relative importance of objects (table 1) [4, 5].

Matrix of pair-wise comparisons provides the ability to perform a pair-wise comparison of items at a certain level of hierarchical structures in terms of their importance for factor, which is at the highest level of the hierarchy [6, 7].

Thus, the matrix pair-wise comparisons is presented in table 2.

Table 2

		1	2	3	4	5	6	7	8	9	10	11	12	13
		Н	М	О	НАС	Ф	СГЕ	АЕ	Б	ФІЗ	С	ОЧ	І	З
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Н	1	4	4	4	1/4	1/2	1/2	1/4	3	3	2	3	1/4
2	М	1/4	1	1/2	1/2	1/7	1/5	1/5	1/6	1/2	1/2	1/3	1/2	1/7
3	О	1/4	2	1	1/2	1/7	1/5	1/5	1/6	1/2	1/2	1/3	1/2	1/7

Cont. of table 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
4	НАС	1/4	2	2	1	1/7	1/5	1/5	1/6	1/2	1/2	1/3	1/2	1/7
5	Ф	4	7	7	7	1	3	3	2	6	6	5	6	2
6	СГЕ	2	5	5	5	1/3	1	1/2	1/2	4	4	3	4	1/3
7	АЕ	2	5	5	5	1/3	2	1	1/2	4	4	3	4	1/3
8	Б	3	6	6	6	1/2	2	2	1	5	5	4	5	1/2
9	Ф	1/3	2	2	2	1/6	1/4	1/4	1/5	1	1/2	1/2	1/2	1/6
10	С	1/3	2	2	2	1/6	1/4	1/4	1/5	2	1	1/2	1/2	1/6
11	ОЧ	1/2	3	3	3	1/5	1/3	1/3	1/4	2	2	1	2	1/5
12	І	1/3	2	2	2	1/6	1/4	1/4	1/5	2	2	1/2	1	1/6
13	З	4	7	7	7	1/2	3	3	2	6	6	5	6	1

The main components of its own vector is calculated as a geometric values in the row of the matrix:

V = (1,221; 0,319; 0,354; 0,394; 3,929; 1,739; 1,935; 2,653; 0,497; 0,553; 0,849; 0,616; 3,532).

The component vector of priorities is calculated [4, 5]:

$$V_n = V_i \Big/ \sum_{i=1}^{n} V_i \qquad (1)$$

V_n = (0,065; 0,017; 0,019; 0,021; 0,211; 0,093; 0,104; 0,142; 0,026; 0,029; 0,045; 0,033; 0,189). This vector defines the priorities of the factors having impact on the experience of mobile applications use. For a visual representation we multiply the vector components by a factor k=1000.

The obtained vector is: $V_n xk$ = (65; 17; 19; 21; 211; 93; 104; 142; 26; 29; 45; 33; 189)

Consistency of weighted factors values is calculated by multiplying the priorities vector (V_n) on the of pair-wise comparisons matrix [8, 9].

The obtained vector is (V_{n1}):

V_{n1}= (0,89; 0,234; 0,261; 0,29; 2,9; 1,265; 1,41; 1,911; 0,362; 0,404; 0,612; 0,45; 2,605).

Approximate value of λ_{max} for assessing the consistency of expert judgment is calculated as the arithmetic average of the vector components [5].

The obtained vector is V_{n2}:

V_{n2}= (13,56; 13,66; 13,68; 13,69; 13,72; 13,52; 13,55; 13,39; 13,54; 13,57; 13,4; 13,6; 13,71).

To assess the consistency of expert judgment we calculate λ_{max}:

$$\lambda_{\max} = \sum_{j=1}^{n} M_j V_j$$

It was obtained λ_{max} = 13.6, which is the main characteristic to set the degree of expert judgments consistency about pair-wise comparisons of factors in problems with

linguistically uncertain factors for their solution the theory of fuzzy sets has been applied. The value of obtained decision is determined by the index of consistency:

$$IU = \frac{\lambda_{\max} - n}{n - 1}$$

The result is $IU = 0.05$. Comparing the consistency index value and a table value for 13 objects (table 3) [5].

Table 3

Number of objects	3	4	5	6	7	8	9	10	11	12	13	14	15
Reference index value	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,54	1,56	1,57	1,59

We get the inequality 0,05<0,1x1,56. This inequality indicates the proper consistency of expert judgment.

The level of convergence is confirmed by the histogram (Fig. 1).

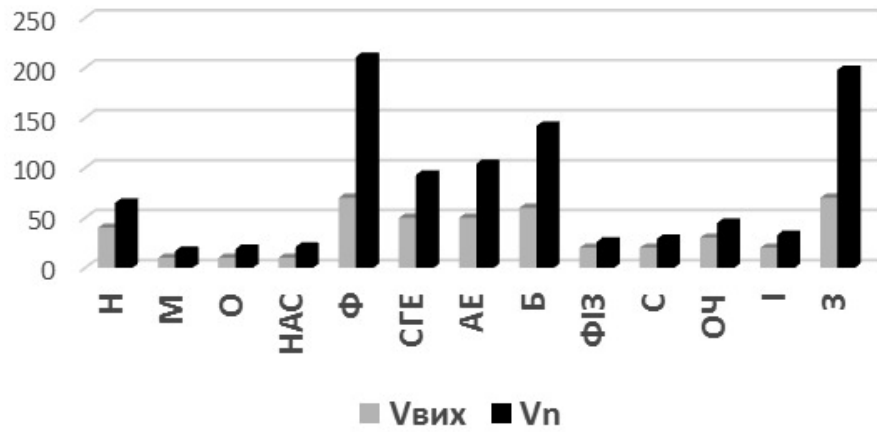

Fig. 1. Comparative histogram of weighting values of initial ($V_{вих}$) and normal (V_n) vectors components

All the components of a normal vector are optimized weight value of factors having impact on the experience of mobile applications use. They have been used to build an optimized model shown in Fig. 2.

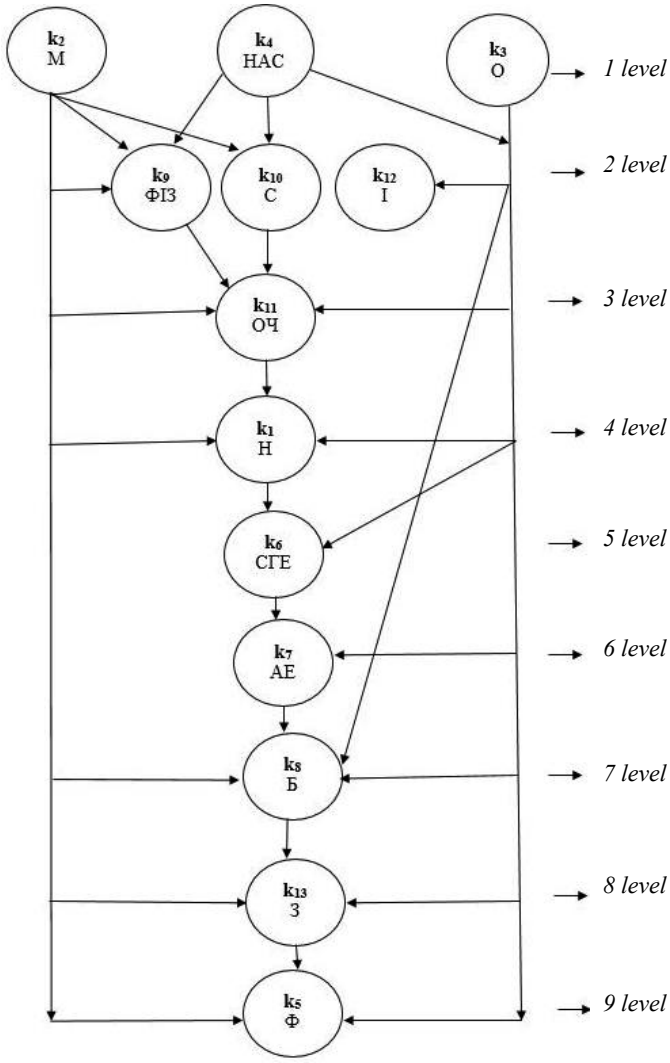

Fig. 2. Optimized model of the hierarchy of impact factors (their dependencies) on the experience of mobile applications use

Conclusions. The obtained optimized model of the of impact factors (their dependencies) hierarchy on the experience and the more efficient use of mobile applications shows that when designing interfaces for mobile applications, the attention should paid to their functionality and compliance with the predefined tasks. Performed investigation proved that the factors of mobile applications users have less impact on the efficiency of their use.

The developed model of multifactor evaluation allows to take into account the peculiarities of the impact factors that occur during the operation, optimize them and provide necessary recommendations on the initial stages of mobile applications design.

СПИСОК ВИКОРИСТАНИХ ДЖЕРЕЛ

1. Google Design [Електронний ресурс]. — Режим доступу : https://design.google.com/.
2. Ergonomics of human system interaction. — Part 210: Human-centered design for interactive systems (formerly known as 13407). (ISO FDIS 9241-210:2009). International Organization for Standardization (ISO). Switzerland.
3. Саати Т. Принятие решений. Метод анализа иерархий / Т. Саати ; пер. с англ. Р. Г. Вачнадзе. — М. : «Радио и связь», 1993. — 278 с.
4. Сорока К. О. Основи теорії систем і системного аналізу : навч. посіб. / К. О. Сорока. — 2-ге вид., переробл. і виправл. — Харків : Тимченко А. М., 2005. — 286 с.
5. Лямець В. И. Системный анализ : вступительный курс / В. И. Лямець, А. Д. Тевяшев. — 2-е изд., переработ. та допол. — Харьков : ХНУРЕ, 2004. — 448 с.
6. Хамула О. Г. Оптимізація математичної моделі ієрархії критеріїв якості сприйняття інформації в електронних виданнях дітьми з вадами зору / О. Г. Хамула, С. П. Васюта, М. Р. Яців // Технологія і техніка друкарства. — 2014. —№ 4 (46). — С.14–20.
7. Хамула О. Г. Оптимізація багаторівневої моделі факторів впливу на проектування композиційного оформлення електронного видання для дітей з вадами зору. / О. Г. Хамула, С. П. Васюта, М. Р. Яців / Моделювання та інформаційні технології. — 2014. — Вип. 73. — С. 204–209.
8. Хамула О. Г. Оптимізація математичної моделі ієрархії критеріїв якості мультимедійних видань з відеоконтентом / О. Г. Хамула, С. П. Васюта, А. М. Терновий / Наукові записки [Української академії друкарства]. — 2016. — № 1 (52). — С. 87–93.
9. Хамула О. Г. Особливості процесу оптимізації математичної моделі ієрархії критеріїв впливу в мультимедійних виданнях з відео інформацією / О. Г. Хамула, А. М. Терновий / Збірник центру наукових публікацій «Велес» за матеріалами II Міжнар. наук.-практ. конф. «Весняні наукові читання», 28 квіт. 2016. — Ч. 2. — К. : Центр наукових публікацій, 2016. — С. 86–92.

REFERENCES

1. Google Design. Retrieved from https://design.google.com/ (in English).
2. Ergonomics of human system interaction — Part 210: Human-centered design for interactive systems (formerly known as 13407) (2009). ISO FDIS 9241-210:2009. International Organization for Standardization (ISO). Switzerland (in English).
3. Saati, T. (1993). Prinyatie resheniy. Metod analiza ierarkhiy. (R. G. Vachnadze, Trans). Moscow: “Radio i svyaz” (in Russian).
4. Soroka, K. O. (2005). Osnovy teorii system i systemnoho analizu (2d ed.). Kharkiv: Tymchenko A. M. (in Ukrainian).
5. Lyamets, V. I., & Tevyashev, A. D. (2004). Sistemnyiy analiz: vstupitelnyiy kurs. (2d ed.). Harkov: HNURE (in Russian).
6. Khamula, O. G., Vasiuta, S. P., & Yatsiv, M. R. (2014). Optymizatsiia matematychnoi modeli iierarkhii kryteriiv yakosti spryiniattia informatsii v elektronnykh vydanniakh ditmy z vadamy zoru. Tekhnolohiia i tekhnika drukarstva, 4 (46), 14–20 (in Ukrainian).
7. Khamula, O. H., Vasiuta, S. P., & Yatsiv, M. R. (2014). Optymizatsiia bahatorivnevoi modeli faktoriv vplyvu na proektuvannia kompozytsiinoho oformlennia elektronnoho vydannia dlia ditei z vadamy zoru. Modeliuvannia ta informatsiini tekhnolohii, 73, 204–209 (in Ukrainian).

8. Khamula, O. H., Vasiuta, S. P., & Ternovyi, A. M. (2016). Optymizatsiia matematychnoi modeli iierarkhii kryteriiv yakosti multymediinykh vydan z videokontentom. Naukovi zapysky [Ukrainskoi akademii drukarstva], 1 (52), 87–93 (in Ukrainian).
9. Khamula, O. H., & Ternovyi, A. M. (2016). Osoblyvosti protsesu optymizatsii matematychnoi modeli iierarkhii kryteriiv vplyvu v multymediinykh vydanniakh z video informatsiieiu. Zbirnyk tsentru naukovykh publikatsii «Veles» za materialamy II Mizhnar. nauk.-prakt. konf. «Vesniani naukovi chytannia», 28 kvit. 2016. Kyiv: Tsentr naukovykh publikatsii, Vol. 2, 86–92 (in Ukrainian).

ОПТИМІЗАЦІЯ МАТЕМАТИЧНОЇ МОДЕЛІ ІЄРАРХІЇ ФАКТОРІВ ВПЛИВУ КОРИСТУВАННЯ ІНТЕРФЕЙСОМ НА ОСНОВІ МОБІЛЬНИХ ДОДАТКІВ

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На базі попередньо проведених оцінок і аналізу факторів, які впливають на користування інтерфейсом девайсів на основі мобільних додатків, побудовано багаторівневу модель пріоритетного впливу факторів (їх залежностей) на досвід користування мобільними додатками. Застосовуючи метод попарних порівнянь і шкалу відносної важливості Саати, встановлено числовий ряд ваг факторів та проведено оптимізацію даної моделі. Здійснено порівняння результатів із попередньо отриманими. На базі цієї моделі можна визначити пріоритети одних факторів відносно інших. Отримані результати підтвердили такі висновки: розробникам інтерфейсів для девайсів варто надавати більшого значення функціональності систем та коректніше формулювати завдання, які треба розв'язати під час виконання певних дій. Як показали дослідження, не варто звертати увагу на бренди та їхні анімаційні можливості, а також на фактори самих користувачів мобільних додатків. Отримані результати оптимізації буде використано для подальших досліджень факторів, які впливають на процес користування інтерфейсом девайсів.

Ключові слова: *фактори, матриця попарних порівнянь, шкала Саати, оптимізація, багаторівнева модель.*

Стаття надійшла до редакції 11.08.2016.
Received 11.08.2016.