Intelligent user interface design of application programs

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Abstract. The modern software is used in all areas of human activity. Application programs allows users to carry out the professional activity at the new, better level. The most important component of any application is the interface on which not only specialist productivity depends, but also quality of the performed work. As the contingent of modern users is very different, it is reasonable to develop the software and its interface part taking into account features of target audience. Use of elements of artificial intelligence at design of application programs will allow to consider features of training of users as much as possible. Creation of adaptive interfaces is caused by high growth rates of functionality of modern program systems, need of simplification of their operation and also to reduction of requirements to the professional level of users. In article the technique of development of the adaptive interface on the basis of individual characteristics of users and also their emotional status is described. Users were divided into five groups: the beginner, normal, confident, qualified and the administrator. Key parameters of individual users characteristics and also their possible emotional states are revealed. The automated system which can create groups based on the analysis of characteristics of users and their emotional state is developed, each group is provided by the adapted prototype of the interface of the application program.

1. Introduction

The interface is important for any program system and its integral component oriented, first of all, to the ultimate user. Via the interface the user judges the application program in general; moreover, often he makes a decision on its use by convenience and clarity of user interface [1].

The complexity of development adaptive interfaces consist in the fact that they have to “please everyone” – to provide convenient intuitively clear access mechanism to information for users of different categories.

Much attention in modern researches of user interfaces development area is paid not only to basic level of work with the computer equipment, but also an emotional state of the user. It is caused by the fact that in modern automated systems users need to process considerable information volumes for limited time. The information overload arising at the same time has an adverse effect on overall performance of users.

Ideally the interface is not only the intermediary, the assistant, but also the means controlling the level of load of the user and his emotional state. Such requirements to development of the interface are primary as the "general" computerization of the population leads to a number of violations of a functional state of mental and physical health of the user.
The interfaces implementing these requirements, as a rule, created with use of artificial intelligence systems, in particular, of genetic algorithms, Markov's models, Bayes's networks, etc. are called intelligent.

A large number of domestic [1-5] and the foreign publications [6-13] oriented for a solution of different tasks is devoted to a problem of modeling of a user interface (creation of the search engines for Internet recommending and the training systems, etc.). Such systems are difficult and quite expensive. Domestic researches are conducted, generally in educational institutions for creation of specialized systems.

The purpose of work to show a technique of design of the adaptive interface on the basis of individual characteristics of users and also their emotional state. Using this approach, the automated system which allows to create groups on the basis of the analysis of characteristics of users and their emotional state is developed, the adapted prototype of the interface of the application program is provided to each of which.

2. Experimental part

The problem of development of adaptive user interfaces concerned LLC JSC Rosneft Oil Company – the Russian oil and gas company, the world's largest manufacturing company of oil. In this organization there is a problem with accounting repair of the oil and gas equipment. To the staff of the organization it is problematic to predict the diagram of technical maintenance and repair to check its execution on time.

Managers of technical support service by means of an automated system are engaged in monitoring of operation of the equipment and the diagram of their repair work. However the staff of this service has different basic level of knowledge of the computer. Therefore, employees with initial level of training should spend a lot of time for searching the components of the menu and the necessary buttons, during the work with an automated system. Managers, processing data on the oil and gas equipment, work in shifts (12 h), practically without breaks, and it negatively affects their attention and speed of reactions. Therefore, the automated system should have the interface adaptive under the professional grade of the user and his emotional state.

Creation of the adaptive user interface is supposed to be implemented in two stages. At the first stage it is necessary to estimate the professional qualities of the user reflecting level of proficiency in the computer. The second stage assumes assessment of an emotional status of the user who interacts with a system at present. On the basis of the analysis of data retrieves it is supposed to generate that prototype of the interface which corresponds to the user.

During execution of scientific research initial types of users were defined: the beginner, the normal user, confident, qualified, the programmer. Professional qualities were defined during the work with the computer equipment [2]. Each of characteristics is evaluated on a three-point scale: high, low and average level (Table 1).

| Characteristic                        | User group          |
|---------------------------------------|---------------------|
|                                       | Beginner | Normal | Confident | Qualified | Programmer, hacker, administrator |
| Computer literacy                     | 0.1       | 0.4    | 0.7      | 0.8       | 1                                   |
| System experience                     | 0.1       | 0.5    | 0.7      | 0.8       | 1                                   |
| Experience with similar programs      | 0.1       | 0.5    | 0.6      | 0.7       | 0.9                                 |
| Typewriting                           | 0.7       | 0.7    | 0.8      | 0.9       | 0.9                                 |
| Intelling                             | 0.3       | 0.6    | 0.7      | 0.8       | 0.9                                 |
| Consciousness                         | 0.2       | 0.5    | 0.6      | 0.8       | 1                                   |
| Color blindness                       | 0.1       | 0.1    | 0.1      | 0.1       | 0.1                                 |
| Concentration of attention            | 0.3       | 0.7    | 0.8      | 0.9       | 0.1                                 |
In the Table 1 levels are designated as follows. High – 0.75-1 point, average – 0.51-0.74 points, low – 0-0.5 point.

Three emotional states belong to the user are defined: quiet, excited and stressful.

In a quiet emotional status the user can fully implement possibilities of the application program, adequately reacts to any messages of a system.

The excited state is characterized by emotional discomfort at which at the user the attention to fine details is lost, it is heavy to it to deal with the difficult menu. In such state it is required to do menu buttons rather large what the user could implement necessary functions of a system at once.

In a stressful state there is overvoltage of mental and nervous character and it is difficult for person to react on actions of a system with full adequacy, there is a slowing down of all reactions. In this state the user spends more time for studying of menu items of the interface, process of work with the application slows down. In this case it is necessary to use more hints, messages for correct work with a system. Thus, on intersection of characteristics of users and their emotional states in an automated system the corresponding user groups for which it is necessary to provide the corresponding prototype of the interface form.

For descriptive reasons representations of work of an automated system the contextual chart in a notation of IDEFO, with structural modeling of BPWIN (Figure 1) was developed.

![Contextual chart in a notation IDEFO](image)

**Figure 1.** The contextual chart in a notation IDEFO.

Decomposition of the contextual chart is presented in figure 2. Development process of adaptive interfaces includes six stages. At the initial stage reference books form. Then the base of estimated means on which assessment of professional qualities and qualities of an emotional state of the user will be made forms.

For assess of an emotional state of the user were taken eight color Lyushera test. When using this test the user is offered to select the most pleasant color from the color tables which are spread out before it, being conformed with as far as this color is preferred in comparison with others at this choice and at present [14].
Figure 2. Decomposition of the contextual chart.

As a result of work of an automated system on the basis of professional qualities and an emotional state user groups to which a certain interface will be provided form. At the final stage there is a direct creation of a prototype the adaptive interface of the application program.

During the conducted research for design of a prototype of the interface adapted for the specific user the method of composition rules of a fuzzy logic was used. Two sets were for this purpose defined: set of user groups and set of templates of interfaces which need to be chosen as much as possible for users with the set characteristics. Input data for creation of adaptive interfaces are the specified sets, and days off of degree of compliance of templates of interfaces of users.

Generally the indistinct relation or, more precisely, indistinct \( k \)-arnym the relation set on sets (universumakh) \( X_1, X_2, \ldots, X_k \) is called some fixed indistinct subset of Cartesian product of these universum. In other words, if to designate any indistinct relation through \( Q \), then by definition \( Q = \{ (x_1, x_2, \ldots, x_k) \mid \mu_Q((x_1, x_2, \ldots, x_k)) \} \) where \( \mu_Q((x_1, x_2, \ldots, x_k)) \) – function of accessory of this indistinct relation which is defined as display \( \mu_Q : X_1 \times X_2 \times \ldots \times X_k \rightarrow [0, 1] \). Here through \( \{x_1, x_2, \ldots, x_k\} \) the train from \( k \) of elements is designated, each of which is selected from the universum: \( x_i \in X_1, x_2 \in X_2, \ldots, x_k \in X_k \).

Binary indistinct relation. Generally the binary indistinct relation is set on basic sets of \( X_1, X_2 \) and is defined as the indistinct relation \( Q = \{ (x_i, x_j) \mid \mu_Q((x_i, x_j)) \} \). Here \( \mu_Q((x_i, x_j)) \) – function of accessory of the binary indistinct relation which is defined as display \( \mu_Q : X_1 \times X_2 \rightarrow [0, 1] \) and through \( \{x_i, x_j\} \) the train from two elements is designated, at the same time \( x_i \in X_1, x_j \in X_2 \) [14].

Besides, for creation of a solution of a task we will need compositions of the indistinct binary relations. Composition of two binary indistinct relations. Let \( Q \) and \( R \) – the final or infinite binary indistinct relations. And the indistinct relation \( Q = \{ (x_i, x_j) \mid \mu_Q((x_i, x_j)) \} \) is set on Cartesian product of
universum \( Q = \{(x_i, x_j), \mu_Q((x_i, x_j))\} \), and the indistinct relation \( R = \{(x_j, x_k), \mu_R((x_j, x_k))\} \) – on Cartesian product of universum \( X_3 \times X_1 \). The indistinct binary relation set on Cartesian product and designated through \( Q \times R \) is called composition of the binary indistinct relations of \( Q \) and \( R \), and its function of accessory is defined by the following expression:

\[
\mu_{Q \circ R}(\langle x_i, x_j \rangle) = \max \left\{ \min \left\{ \mu_Q(\langle x_i, x_j \rangle), \mu_R(\langle x_j, x_k \rangle) \right\} \right\}, \quad (\forall \langle x_i, x_j \rangle \in X_1 \times X_3)
\]

(1)

The composition of the binary indistinct relations defined thus is called sometimes (max-min) – composition or maximine convolution of the indistinct relations.

The indistinct binary relation set on Cartesian product \( X_1 \times X_3 \) and designated through \( Q^* \) by \( R \) is called (max – *) – composition of the binary indistinct relations of \( Q \) and \( R \) if its function of accessory is defined by the following expression:

\[
\mu_{Q^* \circ R}(\langle x_i, x_j \rangle) = \max_{x_i, x_k} \left\{ \mu_Q(\langle x_i, x_j \rangle) \ast \mu_R(\langle x_j, x_k \rangle) \right\}, \quad (\forall \langle x_i, x_j \rangle \in X_1 \times X_3)
\]

(2)

In particular, if in this expression instead of operation "*" to use operation of algebraic multiplication, then we will receive definition (max-prod) – compositions.

The indistinct binary relation set on Cartesian product \( X_i \times X_3 \) and designated through \( Q^+ R \) is called (min-max) – composition of the binary indistinct relations of \( Q \) and \( R \) if its function of accessory is defined by the following expression:

\[
\mu_{Q^+ \circ R}(\langle x_i, x_j \rangle) = \min_{x_i, x_k} \left\{ \max \left\{ \mu_Q(\langle x_i, x_j \rangle), \mu_R(\langle x_j, x_k \rangle) \right\} \right\}, \quad (\forall \langle x_i, x_j \rangle \in X_i \times X_3)
\]

(3)

Taking into account the entered concepts the indistinct model based on two binary indistinct relation by \( S \) and \( T \) was constructed.

The first of these indistinct relations is under construction on two basic sets of \( X \) and \( Y \), and the second – on three basic sets of \( Y \), \( Z \) and \( P \). Here \( X \) are described by a set of interfaces via which set on training, by \( Y \) – a set of professional qualities of work with the computer, \( Z \) – a great number of users, and \( P \) – a set of emotional statuses of the user is carried out. In this context the indistinct relation of \( S \) is informative describes physiological characteristics of interfaces, and \( T \) – physiological characteristics of users.

\( X = \{x_1, x_2, x_3, x_4, x_5\} \),

\( Y = \{y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8, y_9, y_{10}\} \),

\( P = \{p_1, p_2, p_3\} \),

\( Z = \{z_1, z_2, z_3, z_4, z_5\} \).

Elements of universum make the following informative sense:

1) \( x_1 \) – “template 1”, \( x_2 \) – “template 2”, \( x_3 \) – “template 3”, \( x_4 \) – “template 4”, \( x_5 \) – “template 5”;

2) \( y_1 \) – “computer literacy”, \( y_2 \) – “system experience”, \( y_3 \) – “experience with similar programs”, \( y_4 \) – “typewriting”, \( y_5 \) – “intellection”, \( y_6 \) – “memory”, \( y_7 \) – “motility”, \( y_8 \) – “color blindness”, \( y_9 \) – “concentration of attention”;

3) \( z_1 \) – “beginner”, \( z_2 \) – “the normal user”, \( z_3 \) – “experienced user”, \( z_4 \) – “the advanced user”, \( z_5 \) – “the programmer, the hacker, the administrator”;

4) \( p_1 \) – “quiet status”, \( p_2 \) – “excited state”, \( p_3 \) – “stressful status”.

For definition of compliance of the interface to a user group used compositions of the initial indistinct relations. So, (max-min) and (max-prod) – compositions give information on interface template degree to a user group, and (min-max) – composition allows to define a template which is not suitable for this user group [15].

Thus, three models are applied: max-min, max-prod, min-max. Ways for determination of results of composition of the indistinct relations can be the following.

Max-min – composition, or the maximum indistinct convolution:

\[
\mu_B(x) = \max_{x \in X} \left\{ \min \left\{ \mu_A(x), \mu_Q(x, y) \right\} \right\}
\]
Max-prod – composition:
\[ \mu_B(y) = \max_{x \in X} \{ \mu_A(x) \cdot \mu_Q(<x, y>) \} \]

Min-max – composition:
\[ \mu_B(y) = \min_{x \in X} \{ \max \{ \mu_A(x), \mu_Q(<x, y>) \} \} \]

Min-min – composition:
\[ \mu_B(y) = \min_{x \in X} \{ \min \{ \mu_A(x), \mu_Q(<x, y>) \} \} \]

Max-average – composition:
\[ \mu_B(y) = 0.5 \cdot \max_{x \in X} \{ \mu_A(x) + \mu_Q(<x, y>) \} \]

Sum-prod – composition:
\[ \mu_B(y) = \sum_{x \in X} \left( \mu_A(x) \cdot \mu_Q(<x, y>) \right) \]

The algorithm presented in figure 3 was developed for implementation of the described method. The offered interface system provides, due to adaptation, effective work of the user with a system, arranging a system under level of proficiency of the user in the computer, taking into account its emotional state [1].

![Figure 3. Operation algorithm of automated system.](image)

During the work of this algorithm, at the initial stage, in the block of login there is a recognition of the user: for the first time he addresses a system or he constantly works with it. If he is known to a system, then after passing of the test in the block of testing of an emotional state it is allowed to work with a system, previously having configured it for this user. If he addresses a system at the first time, then the interface creates model of this user on the basis of the data received from it. There is a setup of the interface including a desktop taking into account tastes (a font, color, graphics).
3. Results and Discussion
The considered technique is implemented in the software “An automated system of design of adaptive user interfaces”, intended for operation of managers of technical support service on processing of requests for repair of the oil and gas equipment. One of functions of the developed software is the testing of the user implemented in shape “The user's assessment”, in which it is possible to select characteristic and its gradation from dropdown menus (Figure 4).

The developed software keeps the knowledge base about different user groups, taking into account their computer literacy, motility, memory, intellection, color blindness, concentration of attention, etc. And also an emotional state. On the basis of these characteristics different versions of the user interface are provided.

Thus, application of software with the adaptive user interface provides a simple and convenient algorithm of interaction and allows to reduce, or to avoid wrong actions which can lead to catastrophic effects.

4. Conclusion
The main results of work is program also software for a solution of problems of intelligent design of the user interface of application programs taking into account individual characteristics of users and their emotional state.

The following scientific and practical tasks are solved:
- key parameters by which it is possible to classify users when developing the software interfaces are revealed;
- the technique of design of the adapted user interfaces with elements of artificial intelligence is developed;
- the indistinct model on the binary indistinct relations is developed for selection of an alternative template of the interface of the application program.

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