Ergonomic User Interface: System Assessment and Design Process

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Abstract
The article deals with the ergonomic design of intelligent user interfaces. The present state of the problem area, the criteria of quality and efficiency of software, developed. The author proposed new methods of evaluating the effectiveness and productivity of the information the user interface, and explores the user interface design.

Keywords: User Interface (UI), Ergonomics, Intelligent User Interface (IUI),

1. Introduction
Recent decades marks a rapid increase in the use of information technologies in various fields of human activity. Computers, 20 years ago, used for solving highly specialized tasks, are today an essential attribute of jobs in massive types of professions. Irreversible process of computerization of labor makes more urgent the problem of developing effective and reliable means of providing dialogue human-computer mode, suitable for users of different levels.

The development of information systems shows that the competition of products from functional changes in the area of comfort and convenience for the users. The developer there is a problem of UI, allowing for the efficient, ergonomic and economical use of the software. Has long been a technology to significantly improve the UI. However, by themselves they do not make ergonomic interface. For example, in itself a graphical user interface (GUI) is more ergonomic than the text-based interface, and, as experience shows, may be less suitable for use, if developed without taking into account the requirements of ergonomics. Computer ergonomics and the taxonomy of ergonomics have been explored by the author in [12, 19, 26]. For most systems, the development of the UI consumes significant share of the budget and programming effort. The research [1, 2, 3] indicate that: i) UI from 45% to 60% of the code of the program. ii) To develop the UI leaves at least 30 percent of the project budget and an average of 40 percent of the development effort to create a system.

From the users point of view UI is key to understanding the functionality of the program; ergonomic interface severely limits the functionality of the system as a whole. Trends in contemporary interaction of "human-computer" forced vendors to focus on the development of UI. Timely and professional interface development increases the efficiency and performance of the software, reduced the duration of training of users, reducing the cost of processing the system after its implementation.

The rest of the paper is organized as follows: In section one introduction is presented. In section two Applications of ergonomically intelligent UI is presented. In Section three Methods for assessing the effectiveness of ergonomics and UI is discussed. Section four presents The procedure of designing the UI. The author finally presents the conclusions and feature directions in section five.

2. Applications of ergonomically IUI
Intelligent User Interface (IUI) has been proposed as a means to overcome some of the problems that traditional interfaces (such as WIMP, Windows-Icons-Menus-Pointing device) cannot resolve: the problem of information overflow, with implementation in complex systems, cognitive problems Overload in tense situations and other real-time IUI offered as a means to create personalized systems. Intelligence in IUI must make the system adaptable to the user, allowing the dialogue between the user and the system, and to provide information in an integrated comprehensive manner, using multiple modalities and user emotional states has explored in [14, 15].
A well-designed interface should be customizable to the needs of different users, as well as one person in the different periods of his work. The problem of adapting the interface and intellectualization "man - computer" is one of the main directions of research in this field, as in previous years, and in the present. Intelligent interface allows solving the main problem by providing virtually instantaneous output user mode solutions to problems of interest. Intelligent interfaces may have different capacity. The solution of some of the fundamental problems in the IUI results in integration of the results in many ways. In particular, information retrieval, cognitive science, software design, human-computer interaction, computer graphics, information processing in databases, artificial intelligence, system vision, speech processing, agent-based modeling, role-based modeling, software composition modeling etc. has discussed in [11, 17]. In practice, ergonomically intelligent user interface can be used in almost all areas where there is an interaction between people and computers. Special areas that would benefit from the introduction of this type of interfaces are electronic interactive learning system.

![User interaction model](image)

Figure 3. The simplest model of user interaction with the computer

User: I - perceives, II - interprets, III - introduces, IV expect gives;
COMPUTER: I - handles when user enter, II - models (performs); III - displays; IV - waiting;
K1 - delay factor user; K2 - factor execution of the operation; t – Time of operation

\[
k1 = \frac{t1 + t2 + t3}{t1 + t2 + t3 + t4}, \quad k2 = \frac{t1' + t2' + t3'}{t1' + t2' + t3' + t4'}
\]

3. Methods for assessing the effectiveness of ergonomics and user interface

Compliance tasks of user interface are an inherent property of the interface. All the basic functions of the system like input, output, editing and conversion of information is precisely through the interface. In fact, the interaction of the user with a set of hardware and software tools are exactly the interface and the effectiveness of the interface is clear exactly where the class of problems requires the active participation of the user in the design, management, data processing, etc..

The simplest model of the organization of interaction of the user and computer in interactive systems through a modern graphical interface is shown in Figure 3, which defines the ratio of employment to assess the user and use of computers. The analysis of this chart to determine the following requirements for the organization of interaction between user and the computer:

- Providing data output to the system with the workbench immediately after their preparation;
- Formation of the system immediately after they are received; Implementation of a request to perform certain actions in the system.

Interaction should be kept in a form convenient and familiar to users. As follows from the logic of interaction may be two main random factors - think
time and execution time. Stream of requests to the system is usually described by an exponential law, while providing accuracy sufficient for practical use. Query time is usually described by the laws of Erlang [4]. To work with any computer-based system will be convenient; when the user has interacting with the system to feel comfortable. Thus, the impact on the usability of the factors that causes a feeling of comfort. They can be divided into three groups represented in Table 3.[5, 6].

Table 3. Factors that influence the comfort of the users

<table>
<thead>
<tr>
<th>Factors</th>
<th>Causes</th>
<th>Have effects on:</th>
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<tbody>
<tr>
<td>Social factors</td>
<td>Psychological climate</td>
<td>Emotional comfort</td>
</tr>
<tr>
<td>Physical ergonomics</td>
<td>Hardware</td>
<td>Physical comfort</td>
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<td>Psychological Ergonomics</td>
<td>Quality software development, UI software</td>
<td>Mental Comfort</td>
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</table>

If there is a model of the interface, the time it takes the user to perform any clearly articulated purpose for which the interface is provided can be determined. However, the analysis model cannot answer the question of how fast the interface should work. To answer this question, the resort and information theory can be use.

In order to make a correct estimate of the time required to complete the task with the fastest interface, above all, one should determine the minimum amount of information that the user must enter in order to perform the task. This is the minimum amount does not depend on the model of the interface. If the methods of work used in the proposed interface, require the introduction of so much information that exceeds the minimum, this means that the user is doing more work, and so the interface can be improved. On the other hand, if the user is required to enter just the right amount of information that necessary to complete the task, the interface for this task can be done more productive by changing the amount of information. In this case, how to improve the interface (as well as many ways for worse) still remain, but, at least, this goal will improve the performance has been achieved.

Performance information interface (E) is defined as the ratio of the minimum amount of information necessary to complete the task, to the amount of information that the user must enter. The parameter E can be varied from 0 to 1, if no work for the task is required, the output is 1. This is the formal position is introduced in order to avoid division by 0, as in response to the displayed clear error. Performance of E can be equal to 0 when the user must enter information that is completely useless. It should be noted that the interface can be found a lot of details that are of questionable value for the parameter E = 0. An example of such a useless item may be a dialog box in which there is only one, the only way for a user action, such as an OK button.

The parameter E is taken into accounts only the information needed for the task, and information entered by the user. Two or more methods of action may have the same performance E, but have a different runtime. It is even possible that one method has a higher E, but acts more slowly than the other method.

Information is measured in bits. One bit is one of the two alternative options (such as 0 or 1, yes or no), is a unit of information. For example, to select any one of the four sites, two bits of information are needed. To make a selection from a group of eight elements, need 3 bits. Of the sixteen elements - 4 bits, etc. In general, when the number is n the total number of variants of equally transmitted information is defined as a power of 2, which is equal to n log2n.

The amount of information for each option is defined as (1 / n) log2n. If the probabilities for each alternative are not equal, and the i-th alternative has a probability p (i), the information is transmitted to the alternative, defined as p (i) log2 (1 / p (i)). The information content of the interface, which can only be done by pressing a single key, is 0 bits: llog2 (i) = 0.

One can estimate the amount of information contained in the message, but in the context of the entire set of possible messages. To calculate the amount of information that some of the received message, one would need to know in particular the likelihood that the message can be sent. The amount of information in any communication is independent of the other messages that were in the past or in the future, due to time or duration, and is independent of any other events. However, the actions that the user performs the task can be more accurately modeled as a Markov process in which the probability of subsequent action depends on the actions already performed by the user. However, for the consideration referred to just use the probabilities of individual, single events, while we assume that all messages are independent of each other and equally.
One can also calculate the amount of information that is transmitted by devices other than the keyboard. If the display is divided into two areas - with the word "Yes" in one area and the word "no" - in the other, then one click, done in one area will transmit one bit of information. If there are \( n \) equally probable objects, then click on one of these reports \( (1 / n) \log_2 n \) bits. If the objects have different sizes, the amount of information reported by each of them, does not change, but the image while moving the mouse to the smaller objects. This approach to information theory and its relation to the development of the interface is simplified. But even in a simplified form, information theory can give a general criterion for assessing the quality of the interface.

4. The procedure of designing the user interface

UI design has become a separate problem, often more complex than the problem of development of the program code, and requires, as the design process of any complex system, appropriate methods and tools. Current approaches to the design of the UI based on a specific methodological framework that identifies three key problems of the organization of the design process UI: identification of the information required for the design, definition and structuring of the design process itself, and, finally, the objectives and procedures of ergonomic expertise. Figure 4 shows a simplified sequence of stages of designing a UI. Among the tasks that need to be addressed in the design of the interface are:

- Design of an operator to perform specific work created by the system.
- Architecture design and function of the interface;
- Conceptualization and implementation of forms of dialogue;
- Development of communication equipment operator interface, display formats, etc.

All of these problems are interrelated, and are therefore in the process of designing interfaces are solved in sequence. At present there are a large number of approaches to interface design and the vast majority of them are based on the following principles:

- Focus on the potential user (operator) at all stages of the system; Interactive and iterative design process;
- Experimental verification of interface design at every stage of its development.

Innovations in technology and automation control systems extraordinary efforts need to be improved, as UI, and the process of its development. Benefits offered by the new technologies have created a unique opportunity for rapid and effective delivery of information to users.

Ergonomics is included in the design and testing of the product as part of a quality system. Developing a User Interface (UI) design is parallel software in general and mostly preceded its implementation. UI development process is divided into stages of the life cycle [7, 8]:

- Analysis of employment by, association of business functions in the role. Building a custom data model, linking objects to the roles and the formation of new jobs.
- The wording of the requirements for the user experience and choice of indicators to assess UI.
- Development of a generalized scenario of user interaction with the software module and its preliminary assessment of users and customers.
- Adjustment and detailed scenarios of interaction, selection and complement the standard to build a prototype. Development of models and prototypes of the UI and their evaluation in the business game, the choice of the final version.
- Implementation of the UI in the code, create a test version. Develop tools to support user (user dictionaries, hints, messages, help, etc.) and their incorporation into the code.
- Ergonomic (usability) testing is a test version of the UI on a set of previously defined targets.
- Preparation of user documentation and development of a training program.

Almost always, the introduction of information systems increases the overall efficiency of the organization, with a number of studies show that well-designed UI can significantly increase the efficiency compared to just embed UI. Software with ergonomic UI works exactly the way users expect, and allow users to focus on their own problems, not features of the interaction with the system. Ergonomic software easier to learn, they are more efficient, they also help minimize human error and increase the subjective satisfaction of users. Efficient interface is the result of understanding the need to give the developer a considerable attention not only to the data that the user will work, but in fact the user's tasks and activities. [1,2,3] And often the most efficient and EUI can be achieved through the application of IUI [9,10].
5. Conclusions
The author has tried to describe the procedure for the design of modern ergonomic UI. Thus, the creation of ergonomic UI is a promising problem in which there are many outstanding issues, in particular, during the design and testing. Thus it is impossible to overestimate the importance of the intellectual interface, which uses software to significantly enhance its efficiency for the end user.

As shown by the study, the problem of designing intelligent ergonomic user interface for today is highly relevant and popular and has a lot of unresolved and controversial interpreted tasks and decisions.

Future directions of our research will focus on:
The development of a mathematical model of the functioning of intelligent interface in the "human computer", based on the use of user profiles;
Development of general recommendations for building intelligent user interfaces with factors of ergonomics;
The development of mathematical, algorithmic and software intended for the design of intelligent user interface based on the methods and tools of the theory of pattern recognition. The creation of CASE-system to implement a computer-aided design and implementation of IUI for use in web-media and educational systems;
The author has identified the methods for register the Intellectual property (IP) in [28], the same will be implemented for UI;
The development of EUI for affective computing [14, 15], remote user authentication systems [30], social computing [16, 18], Internet banking environment [26], and management information system [20];
The author has worked on software composition models [11], modeling throw roles and ontology [17, 21] and multi-agent system [21]. The same will be used to design an intelligent ergonomic UI.

References