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Designing a Conceptual Model of the Process of User Interface Construction*

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Article proposes a conceptual model of the process of user interface construction for information systems, within which it is proposed to include the user into the design process, which will solve the existing problems of the adequacy of the interface and user activity in the subject area. In this case, the user is invited to compose a description of his activities in the subject area in a language close to natural by himself. The sequence of steps with the participation of the user is presented, which constitute a conceptual model of interface design. The scientific novelty of the research lies in a fundamentally different approach to the interface development, in which the user designs the application forms, relying primarily on his professional activity, and user doesn't need take into account the structure of the stored data or their processing functions, he connects data objects needed to his professional actions. The advantages of the proposed conceptual model are that it becomes possible to consider the user's activity as a whole, and on this basis to build an interface that best suits this activity, which will make the interface more understandable, reduce the level of discomfort when interacting with it, and increase user satisfaction.

Keywords: *user interface, user activity, mechanism of action, semantic approach, activity model, interface design*

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Разработка концептуальной модели процесса конструирования пользовательского интерфейса

Предложена концептуальная модель процесса построения пользовательского интерфейса для информационных систем, в рамках которой предлагается включить пользователя в процесс проектирования, что позволит решить существующие проблемные вопросы адекватности интерфейса деятельности пользователя в предметной области. В таком случае пользователю предлагается самому составить описание своей деятельности, осуществляемой в предметной области, на языке, близком к естественному. Представлена последовательность шагов с участием пользователя, составляющих концептуальную модель проектирования

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интерфейса. Научная новизна исследования заключается в принципиально ином подходе к разработке интерфейса, при котором пользователь проектирует формы приложений, опираясь в первую очередь на свою профессиональную деятельность. Пользователю не нужно учитывать структуру хранимых данных или функции их обработки, он связывает объекты данных, необходимые для его профессиональных действий. Преимущества предлагаемой концептуальной модели заключаются в возможности рассматривать деятельность пользователя в целом и на этой основе строить интерфейс, максимально соответствующий этой деятельности, что сделает интерфейс более понятным, снизит уровень дискомфорта при взаимодействии с ним и повысит удовлетворенность пользователей.

Ключевые слова: *пользовательский интерфейс, деятельность пользователя, механизм действия, смысловой подход, модель деятельности, проектирование интерфейса*

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Introduction

The characteristics of an effective interface of information systems (user productivity, minimal errors; high learning rate, subjective user satisfaction, etc.) depends on various aspects that were or were not taken into account in the interface design [1]. The existing problems in the field of user interface design can be summarized as follows:

- the interface is not adequate to the meaning of users activity (the structure of the user interface is developed in accordance with information flows (structure of objects) within the system itself, and not in accordance with the structure of the real users activity);
- the interface inadequately displays the objects of the system and the connections between them (the relative objects placement on the screen does not coincide with their logical connection or with their importance; redundancy of elements on forms);
- the complexity of the interface modification process;
- the interface is not adequate to the characteristics of users (the skills of using a computer and similar systems are partially solved due to the fact that the user himself takes part in the design and description of activities; the physical parameters of the user; subjective satisfaction when working with the interface);
- the interface is not adequate to the environment of use (for example, the presence of interruptions in user activities and so on).

On the other hand, development of complex information systems and user interfaces as its part requires the collaboration between team members with each other and between team members and users themselves. During the interface development process, we meet the difficulties connected with the correct understanding of the transmitted meaning from one team member to another and to the user at most. This situation arises because all design members are from heterogeneous domains, more precisely they think heterogeneously — within different concepts. So, the final interface can not fit the initial idea.

So user interface development process is usually organized by a life cycle model describing and guiding activities from the initial idea to the final implementation and performance testing, as for example the waterfall model. The problem with this approach is that it is required correct and complete understanding of the complete user interface design project from the beginning, as correcting a mistake made in a previous phase is a difficult and expensive task. Or similar situation, when requirements to the interface are changing during the system usage, is also difficult and expensive while changing the interface. So, it should be proposed some new approach that can help the customers and developers to spend less time and money to the process of interface correcting.

It is possible to try to solve these problems if we propose a way to transfer the structure and content of user activity in the subject area into the interface structure. In this regard, the existing approaches were considered that solve the listed problems in various ways, one of which is the involvement of a subject area expert in the development process [2].

A brief overview of existing approaches to the interface design

Currently, existing approaches tend to involve the user into the design process in the way of co-creation [3], however, different approaches implement user involvement in varying degrees. Many specialists and researchers notice the need for the direct participation of the user, since a software product is not the aim in itself — the goal is to satisfy the user's needs in simplifying his activities by means of a software system. In order to really take into account the needs of the user, it is necessary to constantly interact with him in the design process [4], or give him the opportunity to design the system and its interface by himself. In this regard,

such a direction as End-User Development (EUD) has arisen, which can be defined as a set of methods, technologies and tools that allow users of software systems to create or modify systems or their parts [5].

At the same time, the concept of user involvement in the development process has become an integral characteristic of any approach, only the involvement method differs: in some approaches, the user is engaged through conversation and interviews, while in others it is assumed that the user should do something according to the project by himself [6, 7]. The highest level of user involvement in the process of software systems development is observed in approaches where the user is provided with visual customization tools, after which he can get a finished working system or part of it [8].

Model-oriented approaches can involve user into the process of information systems co-creation in the best way [6, 7, 9, 10—13, 23]. The closest analogue is task-centered design [13]. This approach assumes that there is a detailed description of the user's tasks. Task Model allows to provide the structure and description of the tasks (actions) of the user that he can perform in the software system. Such models should reflect the content of user actions in the system: what should he do and why. There are two types of approach implementation, in the first version the tasks are represented by scripts in text form, in the second version hierarchical task trees are built [14]. The approach also assumes the possibility of assessing the developed interface by establishing a correspondence between the selected tasks and the interface components for whether all the functionality has been implemented [15, 16]. The disadvantage, from our point of view, is that a set of user tasks that he will perform using the designed system is considered, while the general outline of his professional activity is not considered at all, therefore it cannot be said that the problems of adequacy of tasks and their representations in the interface can be fully solved.

Task models are used not only in task-centered design approach but in other model-oriented approaches too. There are two types of task models [6]. The first type aims to reflect the sequence of tasks and their components, and the second — the data streams that are used when performing tasks [17]. But the point stays the same: the actions that the user performs in the subject area are not taken into account in this model, but only actions that directly relate to interaction with the system are considered. Other existing approaches were considered in [18—21].

There are some other types of models that are used in existing model-oriented approaches. The Dialog Model describes the structure of interaction between the user and the system: the structure of transitions from element to element depending on the action performed. As a model of dialogue, behavioral abstractions are usually used, for example, Petri nets, flowcharts, activity diagrams, UML state sequences [16].

The Application Model contains the structure of interaction between the system logic and the user interface, as well as the type of data transmitted during this interaction.

Domain Model is a correspondence of the concepts of the domain and the concepts of application logic and interface. Contains concepts, objects, operations, describing the subject area. The form of representation of such models are the essence of the subject area with the attributes, as well as possible relationships and operations on them.

The Presentation Model contains a high-level view of the interface, including what elements the user interface consists of and how these elements should be presented to the user.

The Behavior model has a similar context with the dialogue model. Describes how the user initiates a dialogue with the system, including a description of the input data, the controls used. The Control model contains a list of functions or operations that can be called, as well as preconditions and postconditions of their call. The Environment model contains the cultural aspect of the interaction context. Usually presented in the form of descriptions in natural language. User model most often contains a description of user characteristics, such as level of knowledge, physical and psychological qualities [6, 17, 23].

None of the above types of models contain explanations of the user's activity in the subject area, they are all at a lower level of abstraction and contain specific options for representing the interface and dialogue, therefore, they are focused on the developer, not on the user. In this case, the user may experience difficulties in checking the compliance of the functionality of the designed system, and the interfaces created in this way may not be sufficiently convenient, which will adversely affect the user performance (the consequences of a semantic gap problem [4, 21, 22, 24]).

As a result of considering the existing approaches to the user interface design, two reasons for the occurrence of the listed problems in the field of interface development can be distinguished:

- a semantic gap, which leads to the fact that the process of performing a task in the subject area is inadequate to the representation of this process in the user interface; a semantic gap arises in the process of communication between participants of the development process, when in the head of each participant there is a transformation of information received from another participant, the meaning of which may be distorted or partially lost;

• orientation of existing technologies for data processing, because most often the interface contains the purpose of data processing in the order in which the developer has determined.

To eliminate these reasons and achieve the preservation of the meaning of the user's actions in the subject area, and also fully reflect the user's requirements in the interface of the information system is possible if to create a common model which will be the same sign form of constructing various models: user activity; business processes at the same time; and it will be the initial data for system model. This universal model will be the result of the joint activity of all participants in the process of its creation, and, consequently, it will be understood and interpreted equally by all participants.

So we suggest approach to user interface development that can help end user and development team to correctly understand each other, and at the same time that can help to simplify the process of managing the interface structure if it is necessary.

Conceptual model of the interface construction process

The proposed approach [20, 25] aims to involve the end user as much as possible in the process of the interface design of the software system necessary for his needs. A user is understood as a competent problem domain specialist, i. e. a person with extensive knowledge and experience that allows him to effectively solve professional problems.

Within the framework of the proposed approach to interface design, the user is invited to compose a description of his professional activity in the subject area by himself.

The scientific novelty lies in a fundamentally different approach to the interface development, in which the user designs the application forms, relying primarily on his professional activity, and user doesn't need take into account the structure of the stored data or their processing functions, he connects data objects needed to his professional actions.

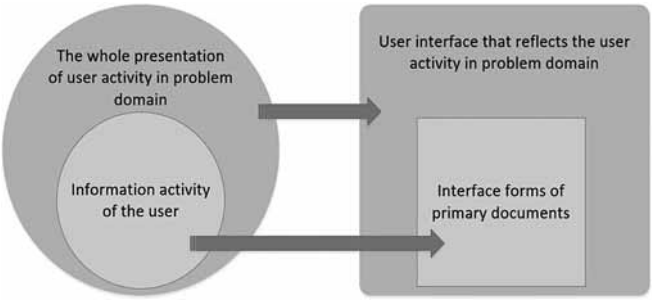

Figure 1. Concept of transformation of activities

As the initial data, a general description of the activity as a whole is singled out (Figure 1), and within the framework of this integral professional activity, informational activity is singled out, which is the activity that will be performed in the system and which is considered in existing approaches when constructing models.

Documents are the object of information activity, since the use of any information system comes down to drawing up, filling out documents based on the results of the activity. Therefore, the implementation of the forms of primary documents is necessary and should correspond to the information activity of the user. Information activity should be tied to professional activity. The interface created by the user should correspond to the structure of the user's professional activity in order for the user to find it convenient to navigate the system.

Conceptually, the model of the user interface design process consists of the following components (Figure 2).

• Description of the activity process in the subject area by the user in a language close to natural, in the form of a tree. Depending on the depth of detail, four levels are distinguished — actions, tasks, operations, steps.

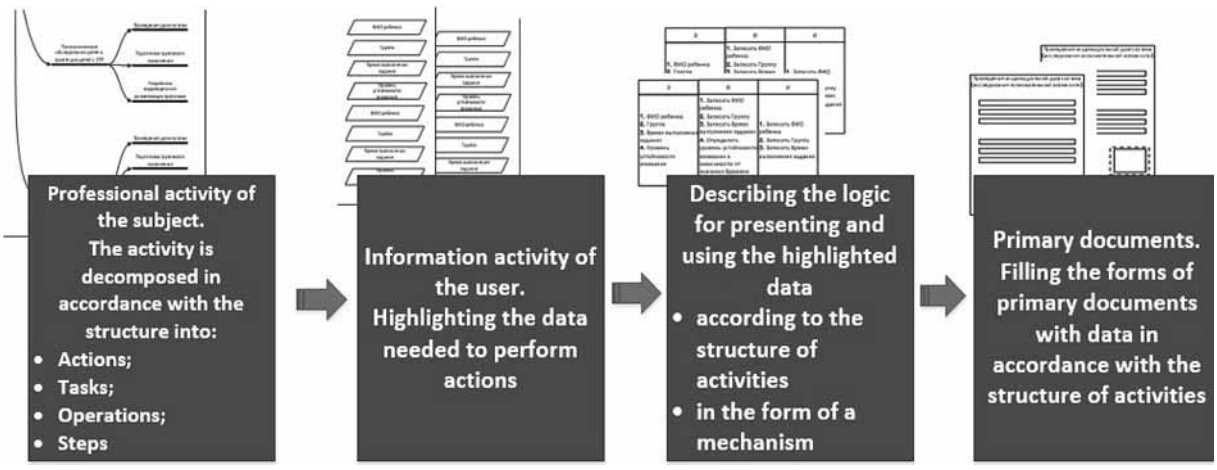

Figure 2. Conceptual model of the interface building process

- For each step of the user's activity, his information activity is singled out, which is the definition of data that are used and processed while the activity is performed.
- Transformation of the selected types of activity (professional and informational) into a model in the form of action mechanisms, in which the user's actions are decomposed to the level of previously prepared standard mechanisms for representing actions in the interface, i. e. there is a process of converting actions and data into document forms.
- Filling forms of documents with data in accordance with the structure of activities.

The interface will be a logically related set of interface forms filled with required controls. The communication logic of the interface forms is based on the connection of action mechanisms.

The process of user interface construction begins with the semantic analysis of the description of user activity made by user himself. It has to be determined the type of user action based on which the type of form is chosen.

Depending on the nature of the user's described activity in performing a certain professional function, a type of form is selected that can assist the user in performing this function. And the structure of this activity influences the filling of the selected interface form type with concrete elements.

So the initial data for the user interface design is the structure of the action mechanisms; the result is a set of related forms filled with related interface elements. Using a set of defined rules, information is extracted from the structure of the action mechanisms and the interface components are obtained.

An interface model which will be adequate to the user's professional activity can have a standard universal structure, which includes the following aspects:

- the level of the model of professional activity (allows the user to navigate in accordance with the state of information system and the stage of his work);
- the level of the information activity model (allows the user to navigate in accordance with the content of the screen forms of the stage of his work and its information results);
- the level of presentation of screen forms (allows the user to enter intermediate data necessary for the automated generation of primary documents);
- the level of presentation of the primary document (demonstrated optionally and allows the user to check the completeness and accuracy of the information entered);
- the level of description of the rules for converting intermediate data into fields of primary documents (demonstrated only at the editing stage and allows the user to describe the processes of filling in the fields of primary documents in subject area terms).

Development of basic modular architecture of platform for user interfaces construction

The first step in design of a platform for interfaces design by the user was the development of a basic architecture.

As part of the work on the platform basic architecture design, its modular structure was determined, consisting of four modules:

- the module of user activity description by the user himself;
- the module for describing the logic of presentation and use of selected data;
- the module for interface elements selection based on action mechanisms;
- the module for the user interface construction.

The module of user activity description by the user is necessary for the formation of user professional activity model. The input data for this module are the documents and functions of job descriptions that the users use in their professional activities. At the output of this module, data objects (information blocks related to the activity) and an activity model are formed.

The module describing the logic of presentation and use of selected data is necessary to describe the user professional actions as a structure of action mechanisms, in order to obtain informational activity. Information activity is a part of professional activity of the user that is performed with the help of information system. The input data for this module are data objects (informational blocks related to the activity). The output is the action mechanisms filled with concrete activity elements.

A mechanism-based interface element selection module is needed to correlate the underlying mechanisms for various interface elements and mechanisms describing logic and presentation and data usage. The inputs for this module are completed action mechanisms.

The input data for the user interface construction module are the model of activity, the documents with which user works, interface elements and action mechanisms for the formation and filling of the forms content. At the end, a ready-made interface is formed.

The developed basic modular architecture of the platform for user interfaces design is shown in Figure 3. The advantages of modular structure usage are presented in [26]. Based on the proposed approach there was developed a module of user interface construction by user himself [27]. The implementation of the module is demonstrated on the example of screens for adding actions to stages, forming an action diagram automatically, and binding functions. After making some actions in module the user gets the model of user interface for information system, which can be

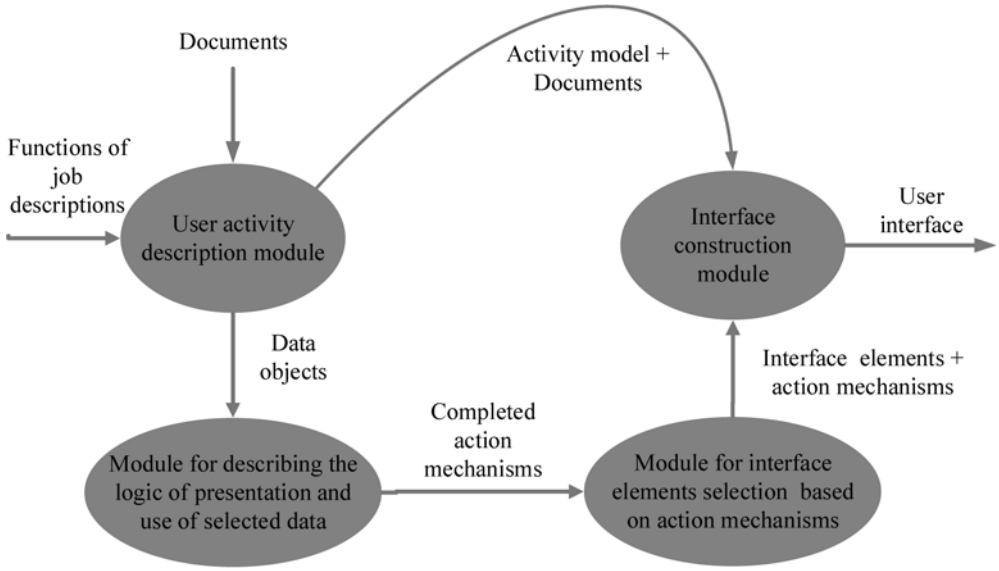

Figure 3. Basic modular architecture of a platform for user interfaces construction

transformed into program code manually, but automatization of this process is under considering.

Since the interface should contain data that is recorded in the process of business operations performing, there is often a problem that the relationship between interface elements is established based on the developers experience (including the basis of artificially formulated requirements for the interface), so usability problems arise, including the complexity of the relationship and redundancy of interface elements on the screen. The developed architecture of the platform solves this problem due to the fact that the connections of the interface elements are established on the basis of a user-defined structure of the task being performed, thereby the structure of the interface corresponds to the structure of the performed business operations so the logic of the business process performing is not broken.

In the developed architecture, due to the fact that the interface is an artificial component, there is a transition from the activity description (the result of the modeling stage) to the interface design by means of transformation: user actions in the domain are presented as they could be represented in the interface — with the addition of technical characteristics related to the structure of future forms, representation of objects in the form of interface objects, etc. The advantage is that it is based on the user's activity, which is presented in the form of actions in the interface. The above problem is solved by placing the empiricism into a strict framework of consideration, the system meaning is preserved in a single complex model. But at the same time, a new task arises — assessing the correspondence between the meaning displayed in the interface and the meaning inherent in the original task.

Conclusion

The idea of user interfaces design proposed in the article differs from the known ones by establishing and reflecting the set, structure and content of user actions within the subject area, while existing approaches do not fully take these aspects into account. This is achieved due to the fact that the source data will be a description of the end user tasks and functions for whom the designed interface is intended.

A holistic representation in the approach of the user professional activity brings the solution of listed problems of the semantic gap, since the use of the presented model allows us to consider the activity of the user as a whole, and on this basis to design an interface that most closely matches this activity, and also allows to reflect the subject area and the meaning of the user's activity in the system's interface. In addition, the approach corresponds to modern trends in involving the end user into the development process. The main quality of the proposed model that helps to manage the interface structure is that if we (or the user) somehow change the high-level description of actions presented with the mechanisms, we can get changing in the interface structure. Also the possibility of loss or distortion of semantic elements is eliminating which allows to design a more effective interface (more understandable for the user, including a decrease in the level of discomfort when interacting with it and an increase in overall user satisfaction).

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