

The Geometrical Principles of Building of Human-Machine Interface for the Control of Multiparametric Objects

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Abstract

The choice of human-machine interface influences on the effectiveness of human work in the management system of complex objects. The realistic view of interface space objects improves their perception by human. The general principles of projecting of interface space are hierarchy, complexity, and objective direction. For solution of each applied task the operator chooses the level of space interface hierarchy that suits according to the detailed nature. In the conclusion area the information space, including both elements of virtual reality, and elements on the basis of other ways of engineering-psychological coding, is created. The reflected scene is built as the aggregate of objects, which are provided with the set of properties, truly reflecting their state in the space and influencing their appearance. The application of the listed principles allows building ergonomic interface for the system of management of technical, social-economic, medico-biological and other objects.

Key words: human-machine interface, monitoring, multiparameter object, geometric principles, hierarchy, complexity, objective approach, space measurement, integral indication, mnemoscheme, detail representation.

On the monitor screen the controlled object state is represented by means of “human-computer” interface. In this case the effectiveness of automated control and management system on the whole depends a lot on the interface choice. Presently the specialists considered many aspects of interface building. There are recommendations on its text recording, colour and compositional decisions, space navigation and dialogue organization with the user [4, 5, 9]. Paying the proper attention to these important issues, it should be also noted that in real world a human interacts with real

objects, the behaviour experience and sensory-motor skills are worked out on the real objects. This means that interface space, maximally closed to the reality is optimal according to ergonomical nature of interface. It is confirmed by the uninterrupted growth of interest to the three-dimensional interfaces, including the interfaces on the basis of so-called virtual environment – representation of the control objects with the increased realness[1, 2, 3].

The most important component of reality of three-dimensional objects is reality of their forms. The rest of reality components (dynamics, texture, illumination) only increases its level. However, the issues of interface space organization, choice of measurement and detail, modelling configuration methods of monitoring objects and other geometric aspects of projecting of human-machine interaction were considered insufficiently. The analysis of achievements in the area of 3D-interfaces and requirements to interaction of the human with the system allows formulation of the general geometric principles of interface space projecting. We can relate the hierarchy, complexity and objective direction to them.

In the aspect of detailed reflection the contradictory requirements are demanded to interface. On one part, the interface must represent object with sufficiently high detail allowing human to make true impression about each control object. On the other part, for the wide cover of the controlled situation on the whole interface must maximize the number of represented information objects that is possibly on the basis of reduction of their detail. The solution of contradiction removal is **hierarchic structure** of interface space. For solution of each applied task the operator must have possibility to choose the suited level of space interface hierarchy. Then, working with one or another level, the human will receive the different knowledge about controlled object or process, i.e. the levels of hierarchy serve as the cognitive interface levels. Such levels can seem parallel or sequent (according to call) to a human on dependence on the accepted decisions of geometric modelling and possibilities of the graphic system.

The applied tasks of monitoring computer system can be very different – modelling, calculations and decision-making. The visual accompaniment of each task must allow effectively solving the task and at the same time not to be superfluous. This means that in the area of conclusion the information space, including both the elements of virtual reality, and the elements on the other ways of engineering-psychological coding as text, colour, forms, mnemonic symbolsetc., must be created. Moreover, on each level the interface hierarchy can use different space measurement: 2D, 2.5D, 3D. For this purpose the interface of computer system must have **complex character**.

For representation of the scene in the form natural for the operator, it is necessary to use customary images and ways of interaction with them for it. Interacting with the real world objects, the human doesn't separate the signs of form in them from the signs of behaviour and state. The similar representation of interface objects provides the integrity of their perception. It can be provided with the help of **objective-oriented approach**. It supposes building the reflected scene as the integrity of graphical objects, which are provided with the set of geometric properties, truly reflecting their state in space and influencing on their appearance. First of all, these

properties include geometric transformation of shift, turn, scaling and projecting in the space of configured measurement. Moreover, in the graphic systems the means allowing the increase of reflection reality are also connected with geometric operations. Thus, illumination modelling of three-dimensional object requires determination of the directions of standards to its surface, and overlapping of the characteristic pattern – texture – on the object lies in the settlement of conformity between textural and geometric coordinates of characteristic points of this object.

Based upon three specified principles – complexity, hierarchy and objective orientation – become understandable tasks of interface projecting:

- separation of monitoring objects and juxtaposition of the interface objects by them;
- separation of the monitoring tasks, determination of their cognitive loading and distribution of them according to the levels of hierarchy of interface space;
- determination of the geometric organization of interface space on each hierarchical level: the choice of quantity and measurement of geometrical space bases, the number of degrees of object freedom;
- the choice of means of geometrical object and scene modelling: types of geometric models, geometric transformation apparatus, means of compositions of complex space constructions;
- giving the objects of the desired degree of reality: determination of the realistic component, substantiation of realistic degree for each level of interface hierarchy, choice of effective means of realistic provision.

We can show application of the listed principles at projecting means of control of multiparametric objects.

The direct monitoring of parameters of complex objects, for example, with the help of measurement devices, indicator and registration devices by the reason of numerousness doesn't provide possibility to evaluate quickly the state on the whole. For reduction of operator labour tension, the forms of object reflections are applied, more adapted to the peculiarities of human perception, for example, mnemonic scheme (mnemoscheme). However, mnemoschemes of multiparametric objects are also very complex and much more time is required for evaluation of the general state of the object.

The state of complex object on the whole can be evaluated according to its integral (generalized) characteristics. The integral indicator serves for its representation. The choice of effective form of integral indicator is the complex technical-ergonomic task, as this form must be customary for the operator and suitable for the one-moment perception. For example, the image of tree, which branches reflect the state of different components of monitoring objects, can be used as such indicator: they are covered with leaves or wither in different situations. The variant of integral indication is so-called "Chernoff Face". Its essence is that the state of groups of the parameters for an object is "tied" to mimic of the human face. At change of the parameters the face "makes mouths" and by its view the operator can judge about the state of object on the whole [8].

However, giving the one-moment of representation about the state of object on the whole, the integral indicator doesn't allow determination of the concrete parameters, which should be effected in case of necessity. The solution is hierarchic representation of the state of complex object on several levels, as it is shown schematically on figure 1 (the arrows indicated the sequence of transition to the hierarchic levels).

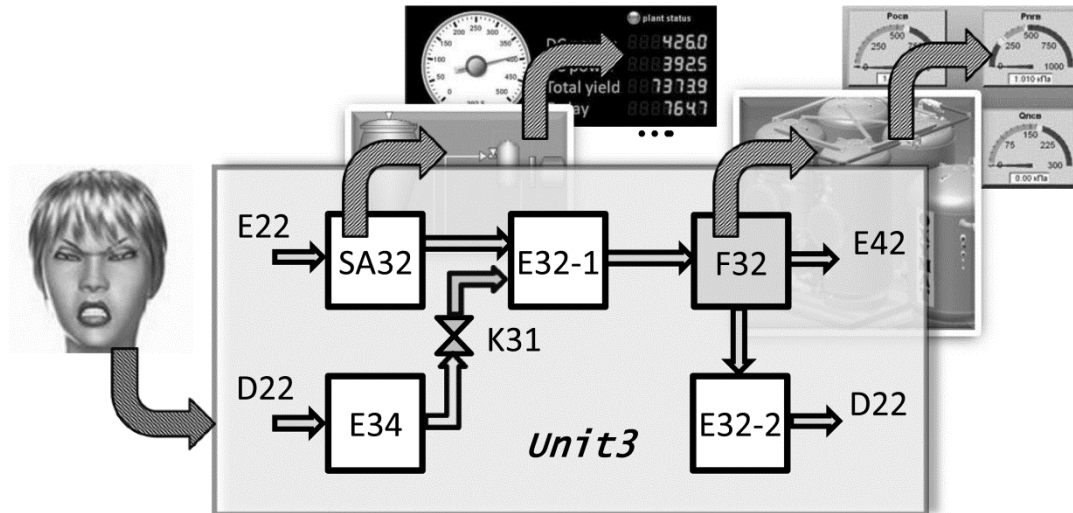


Figure1 – Hierarchic interface for control of multiparametric object

On the upper level of hierarchy, it is necessary to apply the integral indicator (for objects of high complexity – the group of indicators). It is appropriate to build the upper level of interface on the basis of 3D-graphic devices, as the space representation is more informative, than the flat one. For example, in case of usage of three-dimensional analogue of Chernoff Face– “Chernoff head” –the turns, bends and deformations of head can be used as the additional information signs. At the same time, 3D-representation doesn't take much place on the screen, than the flat one. Such integral indicator is executed as the graphic object that corresponds to the object approach.

The detailed reflection of parameters as the control object is imposed on the lower interface levels. The compact representation of the number of parameters is possible by means of 3D-graphics. Then parameters form the thematic layers, for example, connected to the separate components of the object, by which it is possible to move, using the third interface measurement (depth). At that the layers have internal hierarchy: together with movement ahead along the representation becomes more detailed. In particular, for implementation of the lower level of interface hierarchy we can effectively use the possibilities of three-dimensional (multilayer) mnemoscheme, having their hierarchical levels on detailing [6]. By the movement of the manipulator (keyboard, mouse, joystick) the operator can move from one layer of

mnemoscheme to the following one that related to the second block of the reflected object. Such representation of the object structure helps to use one screen for reflection. The choice of separate mnemonic symbol by the manipulator allows seeing the fragment of mnemoscheme with bigger detailing. More detailed representation of one mnemonic symbol that is built as multiparametric graphic object also has hierarchic structure allowing the transit of more detailed representation up to the separate parameters. On the lower levels of hierarchy in accordance with the principle of complexity the text or two-dimensional graphic representation of the controlled parameters is widely used.

The objects of interface space can have any form. In connection with this, the choice of geometrical object modelling method is important. The source data for usually include the set of typical points, irregularly located in the space and set by their coordinates. In such cases for object form modelling, two-stage way is effectively used [7]. On its first stage the determination of the new typical points is conducted, which are regularly set in the space. For regularization interpolation with application of the radial basic functions is used. On the second state the model of object surface on the basis of polygonal network or piecewise-polynomial sections, visualization of such model is possible with the help of quick algorithm is formed.

The offered approach allows within one interface combining integral indication of the system state, necessary for operative evaluation of its state on the whole with detailed representation of the processes, necessary for their quantitative regulation.

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