CAD-system in solving design and inventive problems

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Abstract. The paper discusses the issues of user interaction with the CAD system. The system approach requires the study of the third element - the interface. In addition to the classical subsystem of receiving, transforming and transmitting user requests, the interface model includes testing, statistical analysis and recommendation subsystems. The task of the first subsystem includes an assessment of the user's creative potential, the second reveals the user's preferences and the conditions for their use, and finally, the third subsystem should prompt the user that in some cases there are more convenient tools than the ones he prefers. Further, the first subsystem is investigated in more detail. The experiment was conducted on a group of students in the study of the discipline "Fundamentals of engineering creativity" using two types of tasks: spatial imagination and kinematic thinking. It is shown that, as a first approximation, users can be divided into two classes and force the CAD system to compensate for their one-sidedness, by adding creativity when making design decisions in one case and an analyst in another. Thus, on the one hand, the creative potential of its user develops, on the other hand, the user has the right to demand from the CAD system greater adaptability and intelligence in communication.

1. Introduction
Design automation systems - CAD - systems are effective tools in the hands of practical engineers [1,2]. But even more opportunities these systems provide engineers and inventors [3]. A systematic approach to the consideration of the interaction of CAD systems with a design engineer requires the study of mutual influence, both from the requirements of engineers for the presence of a large arsenal of functions automating his work, and the oncoming traffic from the system in relation to adapting it to a specific user and improving it intelligence, which, ultimately, should serve to awaken the creativity of the engineer, the development of his creative potential. Consider these questions in more detail.

2. Theory
Of course, there are differences in the nature of the objects with which the CAD - system operates: mechanical, electrical, chemical and biochemical, etc. They differ in purpose, that is, for the design of what object they are used: airplanes, automobiles, ships, nuclear installations, etc.

Classical CAD - the system, besides providing the possibility of carrying out engineering analysis, provides the engineer-designer with tools of 3D - presentation, animation of the developed mechanisms and verification of the kinematic scheme for contradictions [4,5]. The use of these tools in turn develops the user's spatial imagination, thinking and spatial vision of the parts of the designed product. After all, the user can, turning the 3D model, look at it from any direction, including the
unexpected for him, from which he could not imagine it. Using animation, the user develops kinematic imagination, assimilates kinematic interconnections in the designed product, at the same time the system checks the possibility of these movements and prompts the engineer the found contradictions.

Additional possibilities open up if a mechanism for adapting to the user is introduced into the CAD system [6]. Due to this, it becomes possible to provide the user with first of all those tools that he most often uses or explain the advantages of more suitable, but less demanded, tools by this user. To ensure such a possibility, the CAD system must accumulate statistics on a specific user, be able to analyze it and provide the most convincing rationales in favor of tools that are poorly understood by the user.

The intellectualization of the CAD system is currently a promising direction for its development [7-9]. Intellectualization can be viewed in accordance with the functions and composition of the CAD system. First of all, the interface should be intelligent. Another important component with intellectual capabilities should be a decision support subsystem, which may also include an explanation subsystem and a knowledge base editor.

The source of knowledge for the intellectual subsystem is the expert. For the "selection" of knowledge from an expert, several methods are used:

1. Questioning.
2. Expert's dialogue with the knowledge engineer in the process, which the expert proposes certain approaches to solving the generated problems.
3. The game. The situation requiring a solution is presented in the form of a game. The expert is required to develop a strategy leading to victory.

Of course, the widespread use of expert systems in CAD is a matter for the future, but the trend towards the intellectualization of computerized systems provides a natural transition from databases to knowledge bases that are thought of as the most important component of promising CAD systems. Knowledge bases are a logical continuation of databases, they support and model some elements of human intellectual activity, while actively using semantic interpretation mechanisms.

3. Model
As a model of user interaction with the CAD-system, we choose a simple system of three components: the user, the interface, and the CAD itself - the system.

It is clear that the center of interaction is the interface. It should contain, in addition to the classical subsystem of receiving, transforming and transmitting user requests, the testing subsystem, statistical analysis and recommendations.

The task of the first subsystem is to assess the level of creative potential of the user. To perform such a function, the subsystem must offer special tests that reveal the level of spatial imagination and kinematic thinking. This is done in order to help the user in the process of creativity, to complement the designed design (or technology) with original design-inventive solutions in the style of the user's thinking.

The task of the statistical analysis subsystem is to identify user preferences and conditions for their use. For this, the subsystem collects statistics on the use of various CAD tools and systems and reveals statistically significant results regarding the frequency and conditions of their use. Further, it prepares the user with the most appropriate tools for the circumstances.

Finally, the third subsystem should prompt the user that in some cases there are more convenient tools than those that the user prefers. With his consent, the subsystem shows how and what the result is achieved.

4. Data and method
In more detail we investigate the first subsystem of the interface. The following problem is proposed as a test for solving: Figure 1 shows the frontal and horizontal projections of the object, while there are no invisible lines. Task: to draw a profile projection.
This task was presented to the student group in the framework of the course “Fundamentals of engineering creativity”. Other tests should evaluate the level of kinematic representation. For example, in Figure 2 shows the original device for drilling wells [10,11]. The task: to understand the kinematics of the device and to identify the existing contradiction. The device implements a special method of drilling, in which the reactive torque is removed from the rock. To do this, the bottom is divided into two drilling zones, respectively drilled in different directions: clockwise and counterclockwise with two rows of drill bits that can change the drilling areas by turning. The equalization of moments is carried out by a differential mechanism, which with the help of a suitable driver and turns the drill bits at the same time changing the internal and external areas.
5. Results and discussion
The solutions to the first task are shown in Figure 3. As you can see there is a simple (rectangular solution), marked in the figure with the letter a), there is a creative solution with index c) with thinking outside the straight lines and angles, and finally there is a combined solution index c). The first decision is characteristic for analytical thinking, the third for creative.

Figure 3. Options for solving the problem of spatial thinking

In Figure 4, the time to solve this problem is represented by histograms for each of the students. Since 40 minutes were allocated for solving the problem, a time longer than this value means that the problem was not solved at all (this situation occurred in two cases). The average time to solve a problem in a group is 29 minutes. This experiment allows us to conclude that the group can be divided into two subgroups. One can be conditionally called analytical, the other creative, since there is evidence in favor of the slowness of creative thinking. Now, depending on which group a CAD user is in, it should work with it using different algorithms, adding creativity to the analytical user and offering more specific solutions to the creative user.

Figure 4. Histogram of problem solving time

Thus, the creative potential of the user of the CAD system is developed and made versatile [12].

6. Conclusion
Thus, CAD - the system in solving design and inventive problems can serve on the one hand the development of the creative potential of its user. On the other hand, the user has the right to demand from her greater adaptability and intelligence in communication. The result of this symbiosis is the appearance of qualitatively new types of equipment, the improvement of technical and economic indicators of the designed products.

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