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Piotr OCIEPKA*

Institute of Engineering Processes Automation and Integrated Manufacturing Systems,
Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland
*piotr.ociepka@polsl.pl

CONCEPT OF CBR SYSTEM FOR COMPUTER AIDED OF MACHINES DESIGN PROCESS

Abstract: The scope of the paper is the presentation of the concept of applying a computer system based on knowledge and design experience into machine design aiding. The Case Based Reasoning (CBR) method is implemented to assist the design process. A formalized description of the method and CBR system structure are given.

1. Introduction

Many activities realized during design process may be computer aided to a varying degree. However, the possibilities of computer applications in this process are various and depend on the kind of the process, its phase and a kind of a designed product. Larger possibilities of the process aid exist in its final phases, especially during realisation of routine design tasks. In case of activities realised in the initial phases of design process, participation of computer means and methods supporting these activities is significantly lower. These are the most creative stages of designing, which can be hardly automated or even aided only. Despite that, there are constant trials of working out the method of computer tools building for supporting these activities.

Development of calculation techniques and artificial intelligence methods enables construction of intelligent CAD/CAE applications that means tools supporting the engineer during design decisions making [1,2,6]. There are trials of obtaining and storing specialist design knowledge and experience, creating on their basis dedicated systems and integrating them with other CAD/CAE systems and computer tools used during design process.

In the article there is presented a concept of computer system, based on knowledge and experience, supporting the design of machines.

2. The range of functioning of the worked out concept

The design process is an intellectual creative process, which course and the results depend in great deal on talent, imagination, association ability and creative invention of the engineer. Besides these factors also computer tools influence the quality of created design solutions, which if expertly applied, significantly accelerate and facilitate engineering work. That is why it is essential to search for computer methods supporting engineering activities [4,5].

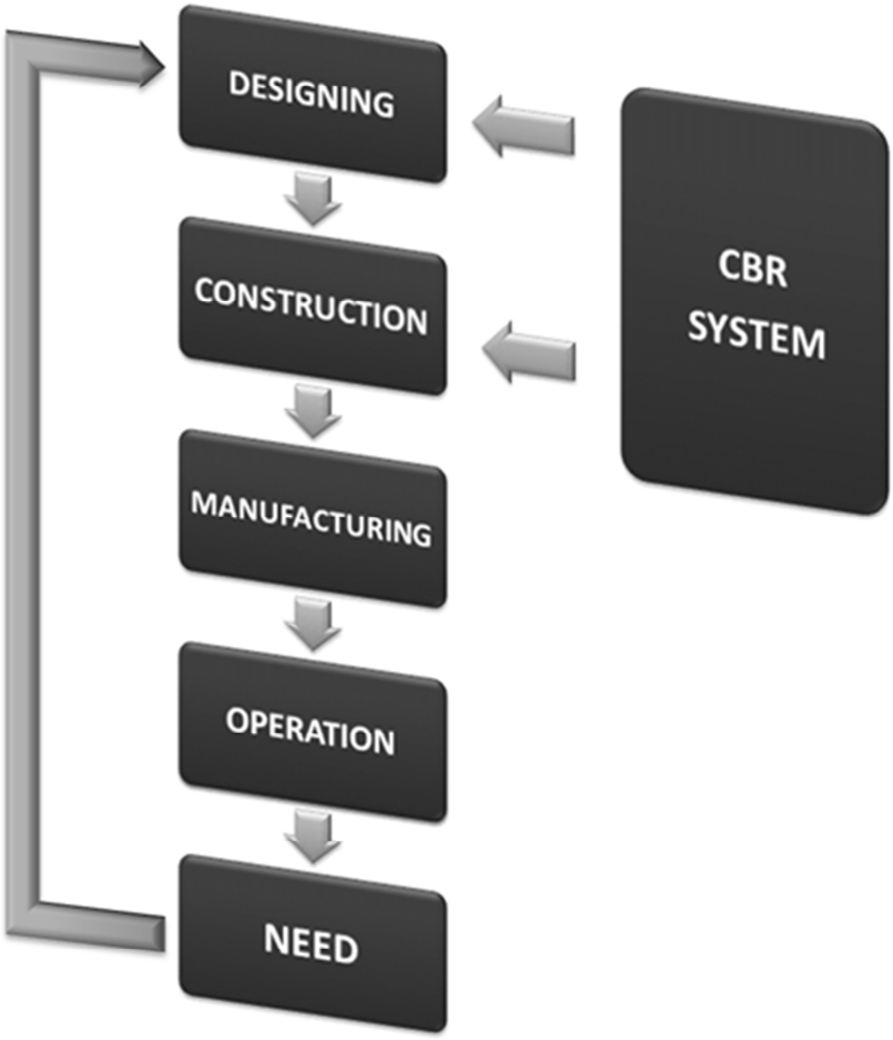

Fig.1. Phases of design process supported by CBR method

The computer system based on CBR method may aid the following design work, realised in the phases of design process (*Fig. 1.*):

- creating of the component functions structure,
- searching for solutions fulfilling the general function and component functions as well as combination of these solutions in order to fulfil the general function,
- valuation of alternative designs in order to determine so called result concept, which will be developed and worked out in further stages of design process,
- searching for construction solutions,
- valuation of construction solutions.

3. **CBR method for aiding the design process**

Case-based reasoning (CBR) is the method of solving new problems based on the solutions of similar earlier problems. CBR has been formalized for purposes of computer reasoning as a four-step process. Given a design problem, ***retrieve*** from memory relevant cases to solving it. A case consists of a description of the problem, its solution, and, typically, annotations about how the solution was derived. Next, ***reuse*** the design solution from the previous case to the target design problem. This may involve adapting the solution as needed to fit the new design situation. Having used the previous solution to the target situation, test the new solution in the real world (or a simulation) and, if necessary, ***revise***. If the solution has been successfully adapted to the target problem, ***retain*** the resulting experience as a new design case in memory. In Fig. 2 there is presented the R^4 model of the CBR cycle.

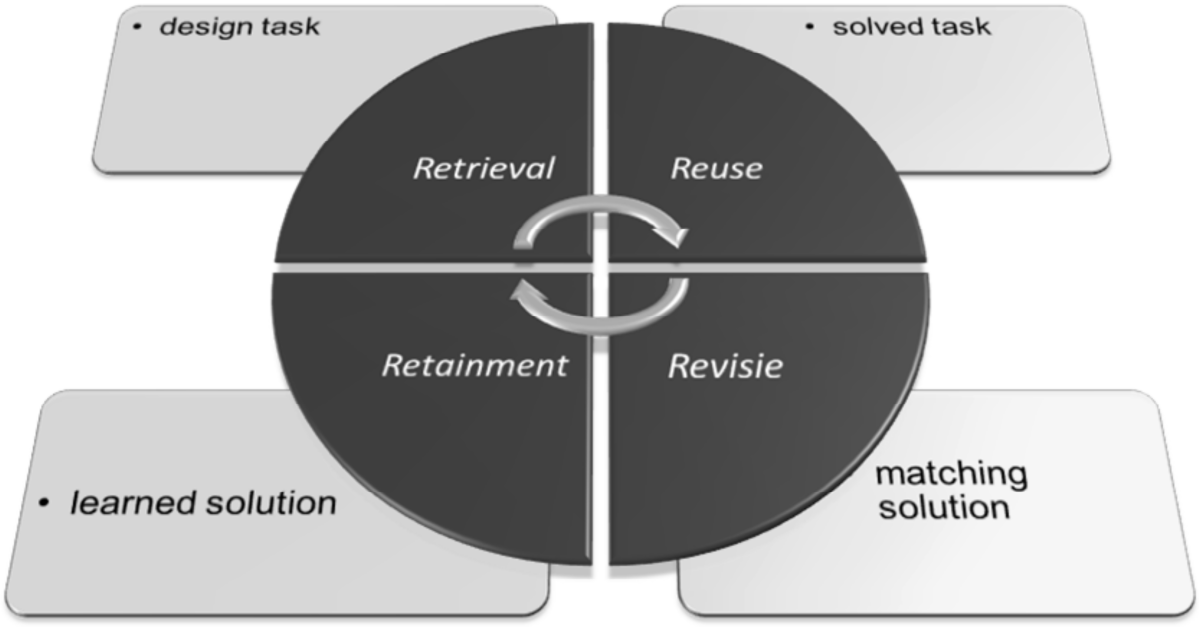

Fig. 2. R^4 model of the CBR cycle

The Figure 3 shows an example of functioning of the algorithm of the system based on the CBR principles. In the first step the system takes the information entered by the user, about the situation of design and construction. Then, based on the entered attribute values and weights coefficients, it finds the most similar cases to the current problem to be solved. In a situation where the system cannot find the appropriate analogy (with the required degree of similarity) the system ends its work. If it finds appropriate cases it sorts the results according to the degree of similarity. In the next step, the user decide whether the degree of similarity of selected cases is sufficient enough to stop searching and to find a satisfactory solution [7,8,9].

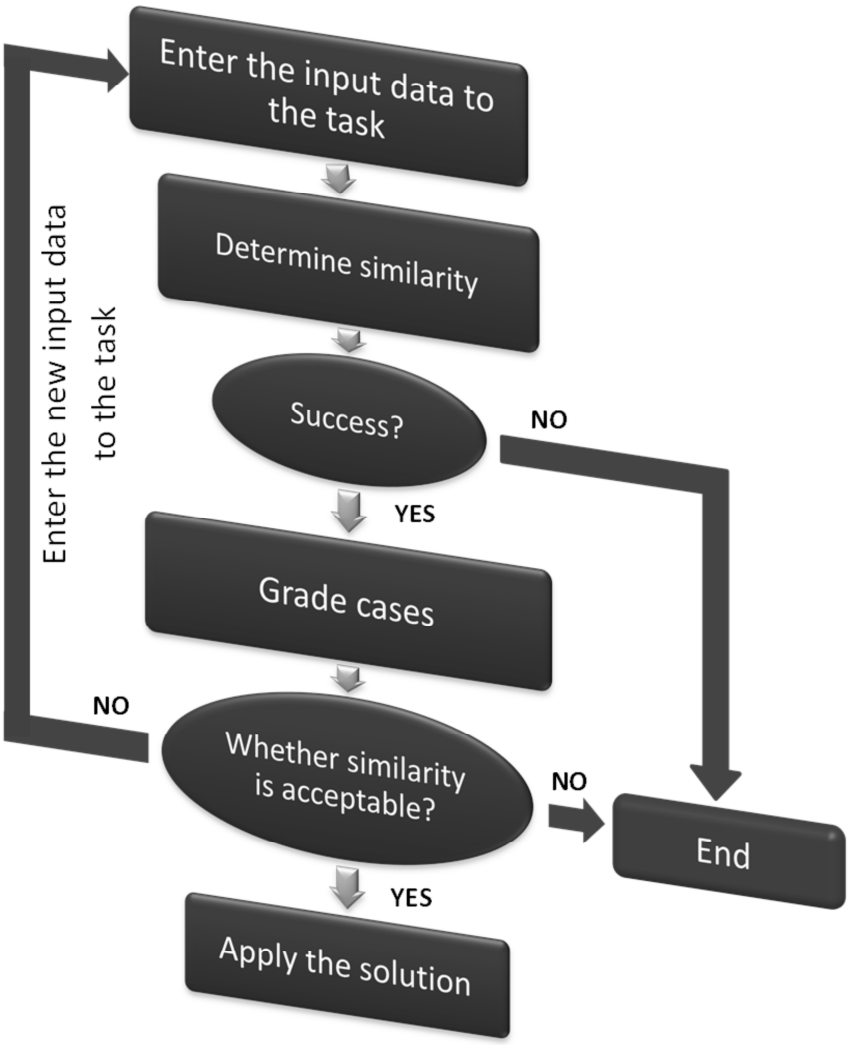

Fig. 3. Algorithm of the system basing on the CBR method

If a satisfactory solution is selected, the system proposes to adapt it. The order proposed by the system depends on the similarity between the current situation of design and the assigned cases.

4. **Formalised description of tasks implemented by means of CBR method**

Task realised by the system based on the CBR method can be described in the following way: given is the description of a project case *M_case* that determines current design situation in the solved task [1,3,10].

$$M\_case = \{ WA_1,w_1, WA_2,w_2, \ldots. WA_j,w_j\} \quad (1)$$

where:

WA_j – value of a *j*-th attribute describing design situation,

w_j – weight of a *j*-th attribute describing a design situation (a number from range <0,1>).

The set of design and construction cases ($Case_s$) created during solving design tasks in the past, is stored in the case base.

$$Case_s = \{ case^1 [SPK_1, OP_1, GRP_1, OK_1, GRK_1], ... case^i [SPK_i, OP_i, GRP_i, OK_i, GRK_i] \} \quad (2)$$

where:
$case^i [SPK_i, OP_i, GRP_i, OK_i, GRK_i]$ – i-th design and construction case,
SPK_i – design situation of a i-th case,
OP_i – description of a i-th design case,
GRP_i – graphical representation of a i-th design case,
OK_i – description of a i-th construction case,
GRK_i – graphical representation of a i-th construction case.

The computing mechanism of the CBR computes similarity degree between model *M_case* and cases stored in the base according to formulas (3) and (4), based on the values of particular attributes and weights stored in the description of *M_case*.

$$Sim(M\_case, case^i)) = 1 - Dist(M\_case, case^i) \quad (3)$$

$$Dist(M\_case , case^i) = \left(\frac{1}{k} \cdot \sum_{j=1}^{k} w_j^2 \cdot \left[M\_case_j - case_j^i \right]^2 \right)^{\frac{1}{2}} \quad (4)$$

where:
M_case – description of a design case
$case_j^i$ – value of j–th attribute in i–th case,
k – number of attributes corresponding with each other,
w_j – weighting factor for j–th attribute.

Based on the results system creates a set of cases with required (expected) degree of similarity $Cases^s$.

$$Cases^s = \{case^1 [SPK_1, OP_1, GRP_1, OK_1, GRK_1], \ldots case^k [SPK_k, OP_k, GRP_k, OK_k, GRK_k]\}_s \quad (5)$$

Than system orders cases according to computed similarity degree and creates an ordered set of cases ($Cases^s{}_u$).

$$Cases^s{}_u = <case^1 [SPK_1, OP_1, GRP_1, OK_1, GRK_1], \ldots case^k [SPK_k, OP_k, GRP_k, OK_k, GRK_k]> \quad (6)$$

Determined, accepted and ordered set $Cases^s{}_u = <....>$ is a set of design solutions, which can be adopted or directly applied to solve a considered design task.

5. Conclusion

The article discusses the possibility of applying the CBR method to support the design and construction of machines. It describes an example of the operation of a computer system based on the engineering knowledge and experience. The use of this method in the process of design

and construction greatly enhances the spectrum of design and construction, which examined and analyzed by the engineer, and reduces the formation of the concept and design. The method can be used to support the design and construction phases of any group of machines. The application based on the proposed method can help to design a routine, innovative, and modular constructions.

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