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CONSIDERATIONS UPON EXPERT SYSTEMS FOR THE DESIGN ACTIVITY IN MACHINE ENGINEERING

BY

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Abstract. Expert Systems are complex programs which simulate the human expert decision making capabilities. The system’s main components are the knowledge database, consisting of rules and facts about the application domain and the inference engine, that computes the result based on the knowldge data. The paper presents an adequate method of organization of knowledge and development of an Expert System, dedicated mainly to design activities.

Key words: expert system, design activity, machine engineering

1. Introduction

Expert Systems (SE), as part of Artificial Intelligence (AI) field, are complex programs that store and process the information using a smart organizational method. This is referred to as the knowledge database and it comes into the responsibility of the human experts to fill it with precise input facts and judgment rules describing the application domain, using languages as

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LISP, CLIPS, and PROLOG and so on. This information is processed by the decision making algorithm, ran by the inference engine, which returns the results needed in high complexity applications. The ESs integrate the competencies of an entire group of experts given the fact that they operate with diversified data, an heterogeneous blend of experiences, that cannot be formalized in an unique algorithm or matched/replaced with just one human expert (Hayes-Roth, 1983).

The Expert Systems are prone to continuous improvement from the user side, since the rules and facts taken into consideration by the program can and should be updated based on the previously obtained results. By simply adding and modifying facts and rules from the knowledge database, the algorithm transforms and gives better results (Alexandru, 2002, Cârstoiu, 1996, Buţilă, 2009).

Expert Systems have been widely used since the 1980s and applied in a numerous different application fields like: engineering, medicine, economy, environmental protection, and so on.

This paper focuses on the Expert Systems dedicated to the design activity, which need the establishment of the corresponding connections that belong to the machine production and exploitation field. The explosive growth of the structural and functional machine complexity requires an overextended activity of anticipatory conception (Buţilă, 2007). The generalization of the dedicated ESs, as applications of Artificial Intelligence, with the modernization of the semi- empirical means of knowledge transfer, comes as a solution to the long necessary period of training of human design engineers.

2. The Content of the Engineering Machine Design

The traditional algorithm for machine engineering design and the corresponding process stages are schematically shown in Fig.1.

The analysis of the design theme consists of identifying the parameters which are difficult or impossible to be reached, pinpointing the economic and ecological restrictions, impossible to be fulfilled and as a corrective measure, re-formulating the design theme accordingly.

The first stages refer to the market research of the existing products and solutions, the current technique level, and the comparison of different approaches through the analysis of the advantages and disadvantages.

The elaboration of the technical solution consists of the actual original implementation, the purchasing of the needed product licenses and addressing other financial aspects and needed resources.

The schematization and simulations consist of the elaboration of base schemes, structural schemes and kinematic schemes, with the use of the drawing IDE (Integrated Development Environment).

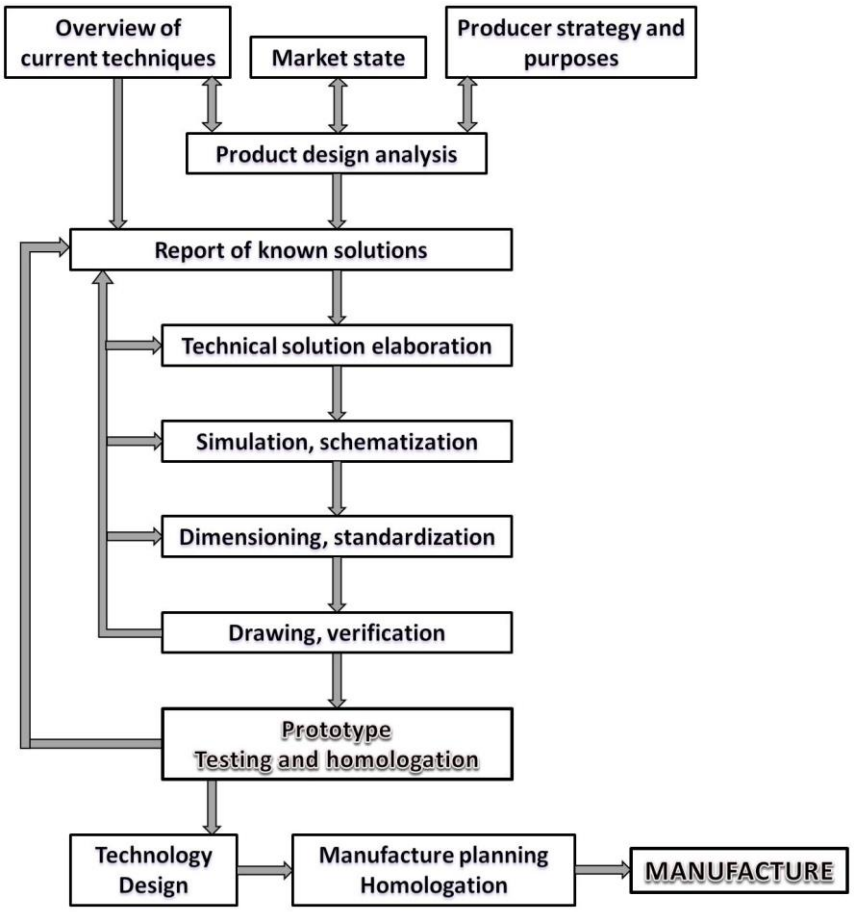

Fig. 1 – The traditional content of the engineering structural design

The dimension algorithms will compute the following:

- The critical situations, through structural analysis
- The choice of calculus methods
- The choice of initial parameters, based on the choice of materials, using expert programs
- The dimensioning, which consists of the establishment of the necessary precision using expert programs, the using of standardization and normalization of relational databases and the result analysis, deciding whether to retake the data or stop the processing.

The drawing and the verification stage consist of:

- The elaboration of the general drawing using the chosen IDE
- The simultaneous carrying out of the verification calculus using simulation and verification programs
- The obtaining of a particular notification
- The resuming of dimension calculus
- The resuming of drawing
- The setting up of technical conditions
- The drawing verification

The testing and the homologation of the prototype imply the usage of special quality verifications programs that will carry out: the measurement of the prototype, modifications of the technical design, modification of the execution design, the modifications of the technical conditions and so on.

The process of machine engineering design includes calculus algorithms and knowledge databases used by Expert Systems to compute the expert like design decisions.

3. Artificial Intelligence and CAD Expert Systems

The Artificial Intelligence is a research domain dealing with the creation of systems capable of carrying out intelligent activities. The main topics of this field are: the representation of knowledge and the searching problem. The first one addresses the aspect of covering the entire field of knowledge required by the intelligent system, in a precise and formal computer language. The searching problem is a problem of systemic searching going alternatively and successively on several levels.

The Expert System is a combination between the theoretical knowledge and a collection of heuristic laws of solving problems (searching results), optimized through practical experience (Luger & Stubbeffeld, 1991).

The general structure of an Expert System is presented in detail in Fig.2 and consists mainly of the following elements:

- The knowledge base – includes the specific knowledge of the application field, in the form of facts, rules and procedures that lead to solving of the specific problems
- The problem solving functions, capable of using the specific field knowledge, ran by the inference engine
- The interaction with the user function that includes explanations for intentions and decisions

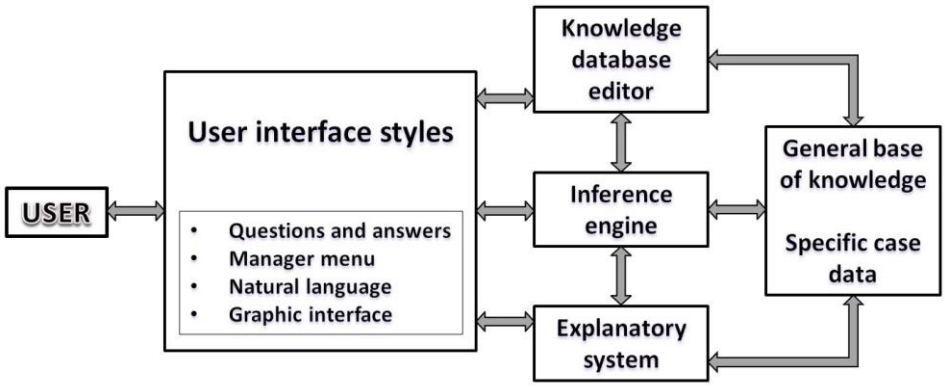

Fig. 2 – The general structure of an Expert System

The main benefits of using Expert Systems are the economic aspect, the lack of full availability of human expertise in all practical situations, automation of rational solving techniques and the increase in the volume of application domain data. Taking in consideration the above aspects and the present development of CAD/CAE integrated systems, it is appropriate to combine the geometrical modeling systems with the knowledge based algorithms, thus obtaining CAD/CAE Expert Systems, also known as the intelligent designing systems.

The Expert Systems shall be regarded as a logical completion of the conventional CAD systems (Mogan & Buţilă, 2004). The structure of a CAD Expert System is presented in Fig.3.

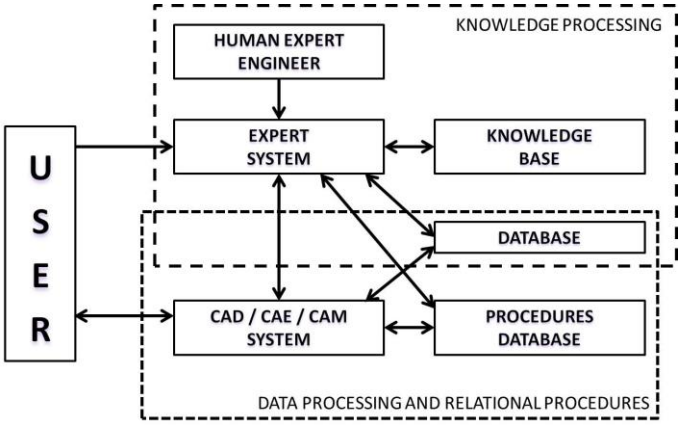

Fig. 3 – The general structure of a CAD Expert System

The role of the computation of behavior simulation is major in such intelligent machine designing systems, the focus falling on clearly defined procedures of verification of a machine design. Even though the algorithms based on the Finite Element Method (Poterașu, 2000, Dumitraș, 2011) are very complex and useful, may solve seemingly impossible and may provide optimizations, they cannot take design decisions. Therefore an important step is for CAD/CAE systems to be capable of making design decisions and of intervening in the case of inadequate design parameters.

Fig. 4 presents the interactions of an Expert System with a CAD modeling system.

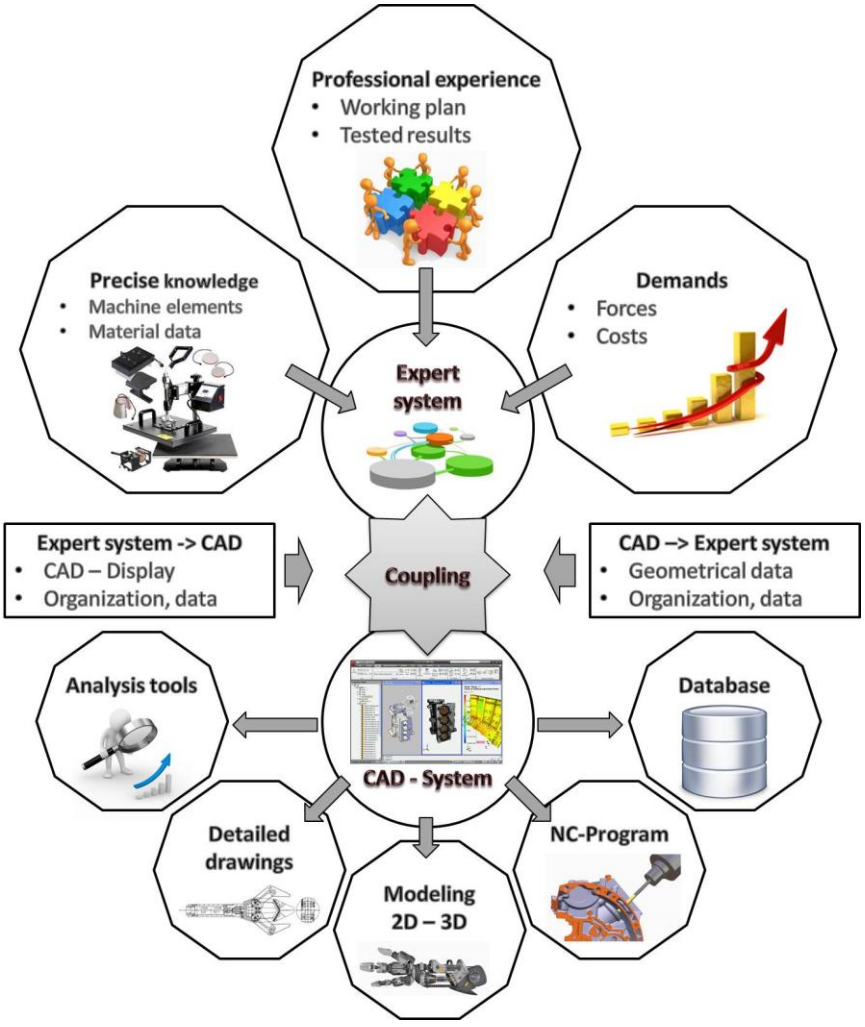

Fig. 4 – A CAD Expert System

4. Conclusions

Intelligent CAD systems are constructed around knowledge databases and constitute an approach to realize high level representations of the designed products by applying the principles of artificial intelligence. These systems solve problems by transferring the knowledge from the human expert source to a complex and efficient program.

The development of an Expert System is possible if the initiator gives the right definition of the solving problem, its field and purpose. It is important that the theme is structured and the characteristics of the design and of the CAD system are translated in the chosen ES language. The inference engine is in charge of selecting the rules from the knowledge database that satisfy the specific parameters of the problem and apply heuristic algorithms recursively until the final solution is reached.

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CONSIDERAŢII PRIVIND SISTEME EXPERT PENTRU ACTIVITATEA DE PROIECTARE ÎN DOMENIUL INGINERIEI MECANICE

(Rezumat)

Sistemele Expert reprezintă programe care simulează capabilităţile experţilor umani de a lua decizii pentru a rezolva probleme complexe. Principalele componente ale unui astfel de sistem sunt: baza de date de cunoştiinţe, formată din fapte şi reguli ce reprezintă abstractizarea caracteristicilor aplicaţiei; motorul de inferenţă, care folosind cunoştiinţele specifice problemei şi aplicând algoritmi euristici, caracteristici Inteligenţei Artificiale, prezintă o solutie finală a problemei.

Lucrarea de faţă propune un studiu asupra aplicării conceptului de Sisteme Expert în proiectarea pieselor mecanice cu ajutorul sistemelor de modelare geometrică, de tip CAD. Sistemele Expert sunt considerate o completare a convenţionalelor sisteme de modelare CAD. Algoritmii euristici de luare a deciziilor caracteristici sistemelor expert pot aduce multe şi importante îmbunătăţiri procesului de proiectare a pieselor mecanice, obiectivul fiind ca în final sistemele CAD expert să fie capabile să ia decizii de design, să intervină în cazul parametrilor necorespunzători, realizând o verificare eficientă a modelului proiectat şi chiar să aleagă materialele optime pentru îndeplinirea cerinţelor funcţionale.