AN EXPERT SYSTEM FOR THE SELECTION OF A COMPOSITE MATERIAL

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Abstract
An expert system for composite material selection starting from the user's specifications was developed by the CNR-CIOC research group of the University of Bologna. Since a DBMS was necessary to manage the amount of information for material and application characterization, a logical interface between expert system and relational data base was developed.

1 Introduction
Composite materials are ancient and new at the same time: wood is a composite! It is possible to assert that man used them from the very beginning but came to appreciate them fully only very recently. From the mid-fifties to now a great number of different materials has been placed on the market. Initially they were treated with suspicion because of their anisotropic behavior, inherent design and manufacturing difficulties especially in most advanced aerospace applications where their high cost was affordable. However, their outstanding mechanical characteristics and flexibility of design, along with an increasing amount of data available facilitated their usage. During the seventies they became quite common, even in not very advanced mass products such as cars, electric household appliances, gardening tools and in fields where structural requirements were not so severe, like ships and buildings. With success many thousands of materials suitable for certain applications, overwhelmed the designer in such measure that standardization was introduced at project or firm level to facilitate the process and reduce logistic problems.

This situation is far from ideal and comparative tables are now quite common in handbooks, scientific papers and commercial sheets. Unfortunately the number of data available is so high that only very few can be listed and only a partial view of material behavior can be achieved. Moreover, not all data are numerically defined and the value of much information should be carefully evaluated, starting from the font and nature. Thus, a simple database inquiry process is not feasible even when the choice is restricted to very few materials. Moreover it is very difficult to deal with data like manufacturing techniques, loading conditions, geometric difficulties, environmental conditions.

For the above reasons it has been necessary to solve the design problem with the aid of a rule-based system able to cope with thousands of materials, each characterized by a great amount of not well structured knowledge; the inferential engine of the rule-based system, with its autonomous decision capabilities can then explore such a complex search space to find a solution which is near optimal either for cost or lightness, or other requirements [ND 88].

The selection of a composite material may be described as follows [WINS 86]: starting from some fundamental specification concerning service, weather, and basic shape of the application, a list of attributes is defined from which a selection is made. A very important attribute is the manufacturing technology needed to construct the part. This technology is inferred from some initial specifications, thus leading to the definition of other auxiliary attributes that can substantially modify the user's specifications or interpret them in order to optimize the solution.

Moreover, the application domain includes a great amount of data, both for the large number of commercial materials, and for the high number of parameters describing them. It has therefore been necessary to store material data in mass memory, with a relational DBMS, and optimize the connection between the expert system shell and the DBMS in order to speed up the selection process.
2 Expert System reasoning process

At first, some mandatory data are required in order to obtain fundamental specifications regarding the basic shape and physical properties of the target part to be realized with composite materials. The basic shape of the part must be introduced using the EUCLID classification of the Brigham Young University. Other questions ask for information about possible mechanical connections and interaction with other components of the machine or structure. Another fundamental point is the final aspect and the service environment of the part, since surface treatments may be necessary. For the environmental problem the world subdivision in climatic zones of military STANAG specification has been used. To complete this description some particular classes have been added to take into account the possible presence of chemical agents (acids, hydrocarbons, solvents), and four different operating positions were defined: outdoor, indoor, covered, indoor with air-conditioning.

After this questioning session the system infers the list of specifications to be used for a first, tentative selection. Maximum and minimum service and storage temperature are determined, the possibility of machine tooling is sometimes added, and further questions may be asked of the user.

For example, an approximate load configuration may be requested, starting from the basic shape introduced, in order to infer manufacturing processes that fit these specifications. This parameter is very important; in fact if the manufacturing technique is too costly, the final cost will be greatly influenced by this parameter; on the contrary, a relatively cheap construction process may increase the relevance of the raw material cost.

Furthermore, a particular manufacturing process may require machine tooling. For this reason the expert system defines a list of specifications for each possible construction method and runs external processes to execute the selection on the database. In particular, auxiliary parameter files are written by the expert system and read by the interfacing programs that perform the data-base queries. After the above-described process, the expert system reads the result of the data-base search and outputs the selected materials, listing them according to the priorities defined by the user (for example cost, lightness, etc...). The figure shows the functional architecture of the system.

3 Some notes about implementation

This implementation exploits the Nexpert (by Neuron-Data) expert system shell in Microsoft Windows environment and interacts with a DBaseIII (by Ashton-Tate) database in which all available composite materials are stored. This configuration allows a complete separation between the database problem of material characteristic management and the expert system, rule oriented material selection problem.

References
