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Prediction of total manufacturing costs for stamping tool

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Abstract: For preparation of a proper offer in tool-making industry the most frequently the values of total cost for manufacture are needed. Because of lack of time for making a detailed analysis the total costs of tool manufacture are predicted by the expert on the basis of the experience gathered during several years of work in this area. In our work we conceived an intelligent system for predicting of total cost of the tool manufacture. The system is based on the concept of case-based reasoning; on the basis of target and source cases the system prepares the prediction of cost. The target case is the CAD-model in whose certain production costs we are interested, whereas the source cases are the CAD-model of products, for which the tools had already been made, and the relevant total costs are known. The system first abstracts from CAD-models the geometrical features, and then it calculates the similarities between the source cases and target case. Then the most similar cases are used for preparation of prediction by genetic programming method. The genetic programming method provides the model connecting the individual geometrical features with total costs searched for.

Keywords: Prediction of costs; Tool-making; CAD-model; Intelligent systems; Genetic programming;

1. INTRODUCTION

The capacity of the tool-making shop to respond quickly to the enquiry is an important factor of competitivity. On the basis of the enquiry it must obtain the answer to the following question: “How much the tool will cost?” The answer to this question, too, is very important, since only if it is precise, on the one hand the preparation of a competitive offer is possible and, on the other hand, undertaking jobs, bringing loss, is avoided. The tool price is limited upwards and downwards since the tool-makers cannot afford additional reserves in price because if the price is too high it is not competitive on the market and the order is not awarded. Contrarily, if the price is too low it brings loss to the company, which is not to the interest of the tool-maker.

In the stage prior to undertaking an order the tool-making shop is busy with the problem of specifying the technological features of tool. It has available scarce, usually only geometrical and physical information about the final product on the basis of which it must prepare its offer. The tool manufacture is a complex process including a variety of personnel, machines and technologies. Therefore, specifying the technological features, including the manufacturing costs, poses a serious problem. In addition, this activity is very time-limited. The output of this activity is of key importance for securing an order and for the business success of the order secured.

It can be claimed that the problem of prediction of the total manufacturing costs has not been satisfactorily solved. Prediction relies too much on subjective influences of the expert. It is evident that the described problem needs a better solution. A system is needed in the offering stage to be able to determine the tool manufacture costs directly from the CAD-model of the finished product fastly and without the necessary expert knowledge.

This paper comprises four sections. The introductory section presents the problems of the tool-making industry occurring in preparation of the order. The second section presents the model of the intelligent system for cost prediction. The subsections explain the present situation of cost prediction and. In the last section the results are discussed and the guidelines for future researches indicated.

2. MODEL OF INTELLIGENT SYSTEM FOR PREDICTION OF TOOL MANUFACTURING COSTS

2.1 Present situation

Although many methods of prediction of the tool manufacturing costs have been developed, the intuitive cost prediction is most frequently used for the reasons stated in the introduction. It means that for prediction of the manufacturing costs tool-makers use particularly their experience acquired in manufacture of similar tools. That experience is gathered in the form of expert knowledge of the employees. Thus the offers are prepared by experts, well familiarized with the tool manufacture, in cooperation with tool designers and tool manufacturing method engineers. The expert works out the prediction on the basis of the product CAD-model observation and the scarce additional information. In a not quite clarified manner he relates the shape and the size with costs. Consequently the quality of the price thus obtained depends on subjective factors. Subjective human judgement has the predominant role in predicting the greatest share of costs.

Such cost prediction is used since it is not demanding with respect to time and cost. However, this approach is today obsolete and the problem requires a better solution. It is interesting that the cost prediction for the needs of preparation of offers in the customer multi-project environment has not yet been better solved, particularly if the importance of this activity from economic point of view is taken into account.

In all methods developed so far, difficulties are met, which have not yet been satisfactorily solved. Associations between geometrical information and tool manufacturing costs practically cannot be covered by deterministic methods. Therefore for the determination of dependence between the geometric features and the manufacturing costs the artificial intelligence methods have been used. By using these methods we have tried to avoid difficulties arising in describing the complex system by deterministic rules. We have conceived an intelligent system using the principle of operation of the analog and parametric methods. Thus the hybrid model of the case-based reasoning concept using the genetic programming method for reasoning has been formed.

The so-called intelligent system is similar to the natural intelligent system, i.e., expert. Like the expert the system has the memory structured in the form of relation data base. While the expert uses his intelligence for reasoning, the artificial system uses genetic programming method.

2.2 Description of model

The model is built on the basis of the improved model of the global cost prediction and the case-based reasoning concept 1, 2, 3. For preparing the prediction it uses the following steps:

- Collecting the geometrical and technological information in the computer data base.
- Abstracting the geometrical features from the target case (CAD-model of product).
- Selecting the most similar cases (source cases) from the data base.
- Working out the formula for cost prediction.
- Use of formula – preparing the prediction.

Source cases are necessary for the use of case-based reasoning. Therefore, geometrical and technological information must be collected in the company. It is saved in the data base as logically connected geometrical and technological information about the individual cases. Selection of the source cases most similar to the observed case facilitates searching for the dependence and preparation of the formula and ensures higher precision of the prediction. In the next step, the parametric dependence is prepared by system for genetic programming. In the last step the resulting parametric dependence is used like in the case of ordinary parametric method.

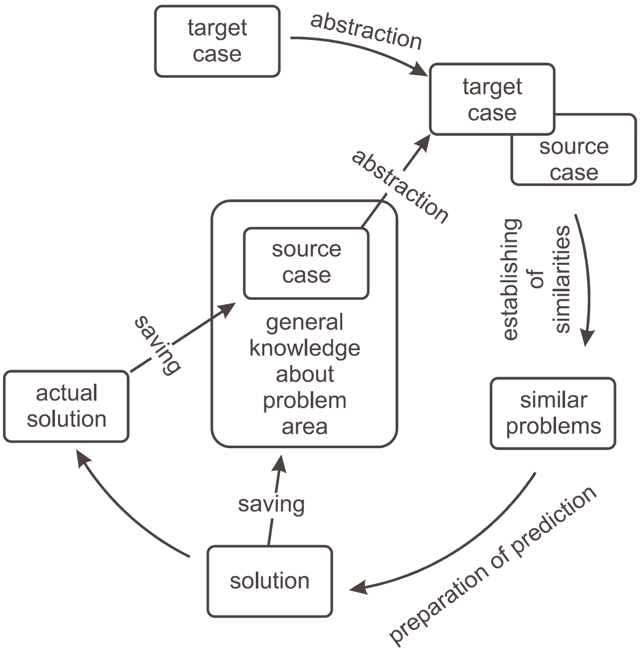

Figure. 1. Case based reasoning cycle in predicting total costs

As soon as the system has obtained a new case, i.e., the problem description in the form of CAD-model for which it must predict the value of cost, it must bring it into the form which the system understands. We must be aware that by today's artificial intelligence it is impossible to treat the entire product model as perceived by the human. However, even the experts do not have in memory the complete information about the product but only the most important parts and summaries. The system first abstracts the geometrical features from the CAD-model. Most frequently, this means that the system isolates the physical properties, the quantity description of the product and the geometrical features from the CAD-model. Geometrical description of the product at the level of geometrical features is the most appropriate because in the individual geometrical features also the technological data significantly influencing the cost are hidden. Example: geometrical feature – hole in the stamped products requires a punch in the tool to make that hole. The output of abstraction of the CAD-model is a record of the problem in vector form. The individual features are comprised parametrically as components of that vector. In the next step, the similarity of the target case against other cases saved in the data base is calculated. The similarity is calculated as the distance between the final points of vectors in the vector space. The greater that distance the smaller the similarity between the two products. In the further step, those most similar cases, which are then the input into the reasoning subsystem, are chosen. For isolation of those most similar cases the absolute or relative criterion can be used. Those isolated cases are the source cases for reasoning about the solution of the target case.

For reasoning about the solution on the basis of similar cases the reasoning subsystem uses the artificial intelligence method – genetic programming 4. The genetic programming method forms the solution in accordance with evolutionary principles. Here the source case components are the programme terminals. For evaluation of the solution the system needs the value of costs the solutions of the most similar cases, therefore, in this step it transfers them from the data base. The output of this subsystem is the dependence between geometrical features and costs, expressed by formula. The task of the subsystem for use is to apply that formula to the target case.

Figure. 1 shows operation of our model through case-based cycle.

3. CONCLUSION

We have conceived a general concept of the intelligent system for predicting total manufacturing costs of tools on the basis of the CAD-model of the finished product. We have decided on building intelligent system due to awareness that the problems treated cannot be solved by deterministic approaches. The system built on the basis of our model is viewed as useful particularly in preparation of offers for the manufacture of tools on the basis of CAD-model of the finished product. The objective of our model is not to surpass the expert but to support him and maybe to replace him in the future. Our further researches will be oriented into testing and fine tuning of our system.

REFERENCES

1. K.-D. Althoff and B. Bartsch-Spörl, Decision Support for Case-Based Applications, Wirtschaftsinformatik 38 (1996) p. 8-16
2. J. K. Kolodner, R. Simpson and K. Sycara, A Proces Model of Case-Based Reasoning in Problem Solving. Proceedings IJCAI-85. Morgan-Kaufmann, Los Angeles, (1985) p. 284–290
3. J. K. Kolodner, An introduction to case-based reasoning. Artificial Intelligence Review. Vol. 6 No. 1 (1992) p. 3–34
4. J. R. Koza, Genetic Programming: On the Programming of Computers by Means of Natural Selection. Cambridge, Massachusetts: MIT Press, 1992