ON EVALUATING REQUIREMENTS FOR DESIGN

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Abstract

A new method is proposed for representing knowledge in design. A frame like representation of artificial intelligence and a value engineering approach are the main components of this evaluation system. This paper points out some of the necessary formalisms for creating an expert system.

Introduction

With the introduction of computers into various fields of engineering a growing demand came up for the creation and implementation of new, qualitatively better design techniques. A rapid development to satisfy these requirements has been possible especially since a number of expert systems has become involved in carrying out numerous design and manufacturing activities. Furthermore, the theory of design was expanded as it was necessary to give a solid basis to new born relations in industrial automation.

The growing complexity of the design process has brought a number of new problems to those which so far have been underestimated. One of the major problems is the availability and usefulness of information for design work which is handled almost entirely based on experience. We would like to propose a new method for representing, storing and processing knowledge for design work which will combine some of the artificial intelligence and value engineering approaches. We feel, that a good systematic method for handling information concerning design requirements could mean a considerable improvement in the quality of design solutions. This paper, however, should be considered as an introductory study and will be supported by experimental data and detailed theoretical description.

Classification and representation of information

Collecting necessary data is often a hard task limited moreover by human capability and errors. Besides, customers' information is of a non-professional, applicational type and is rarely of use to the designer. It means, that the major factors for judging the available information are the experience and learning ability of the designer himself. It is the designer who performs mapping between concepts of the available requirements and specifications for the physical (primary, secondary etc.) and functional architecture of the object (product). At this stage it would be useful to apply value engineering to identify and eliminate unnecessary costs, in the following four phases (Fig. 1):

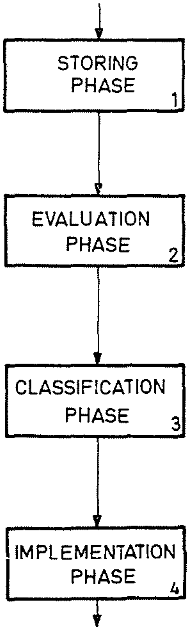

Fig. 1

1st phase — collection and selection of the important function of the object.

2nd phase — evaluation of methods to achieve the selected functions.

3rd phase — exact determination of the chosen method (for example costs, benefits, etc.)

4th phase — implementation plan and control.

For implementing, some frame-like representations of artificial intelligence will be used. Every object to be designed (product) will be described by attributes (requirements) and their value, as shown in Fig. 2. The corresponding values of different objects will be compared according to a rule-based "scaling" matching a necessary situation. The functions of the object and their relation to attributes will be given by a functional matrix F according to the following scheme: if the attribute present in the performance of the function will be assigned a value of one and represented as an element in the F matrix (a23 $=1$) and zero otherwise (Fig. 3).

Attribute	Value
A1	2ø5
A2	Green
A3	Steel
	⋮
Object	

A1... size
A2... color
A3... material

Fig. 2

$$F = \begin{array}{c|ccc} & F1 & F2 & \cdots \\ \hline A1 & a_{11} & a_{12} & \cdots \\ A2 & a_{21} & a_{22} & \cdots \\ A3 & a_{31} & a_{32} & \cdots \\ \vdots & \vdots & & \end{array} \qquad \text{for example } F = \begin{vmatrix} 0 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 1 \end{vmatrix}$$

functions

Attributes

F – functionality matrix

Fig. 3

Using another kind of evaluation a comparison will be made of the attributes by pairs and the result will be fixed in the P matrix. In this way the attribute relation for a given situation will be established from another view, without considering their values. An element of the P-matrix is assigned a value as follows: if the first attribute taken into consideration is more important than the second then an element of the matrix will be valued by one (f.e. a23 $=1$) resp. zero (Fig. 4). In Fig. 5 we give an example of a P-matrix representing the same object in a different situation. Two vectors can be considered, as follows:

$$\begin{aligned} P_1 &= (a12, a14, a23, a34) \\ P_2 &= (a13, a14, a23, a24) \end{aligned} \tag{1}$$

$$P = \begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ a_{31} & a_{32} & a_{33} & a_{34} \\ a_{41} & a_{42} & a_{43} & a_{44} \end{vmatrix} \quad \text{P-positivity matrix}$$

For example:

P =	A1	A2	A3	A4
A1	-	1	0	1
A2	-	-	1	0
A3	-	-	-	1
A4	-	-	-	-

for P_1

Fig. 4

P =	A1	A2	A3	A4
A1	-	0	1	1
A2	-	-	1	1
A3	-	-	-	0
A4	-	-	-	-

for P_2

Fig. 5

In this case (1), we seek for similarities between the circumstances in which the object discussed has been designed. As we can see the vectors P_1 and P_2 give the following conclusion:

$$\text{A1} \leftarrow \text{A4} \quad \text{and} \quad \text{A2} \leftarrow \text{A3} \tag{2}$$

All of the above-mentioned views represent our new method. The necessary matrices represent a formal description of the object to be designed. We believe that this method, if implemented, will represent a type of decision support tool or even an expert system.

Conclusion

This paper should be considered as an introductory research intended to point out the direction of further developments. An LISP implementation of the discussed method will be carried out with some sets of experimental data. We would like to draw the attention of the reader to the possible financial benefits of our method (Fig. 6). Furthermore the following remarks should be made:

1. In case of the P-matrix, optimization will be carried out to determine a good relation between the number of used requirements and the number of discovered similarities as shown in Fig. 7.

2. A suitable user interface and a creation of an interaction "engine" is required to complete a basical level of an expert system.

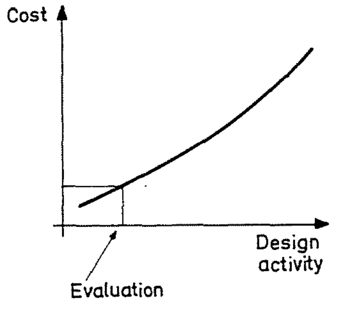

Fig. 6

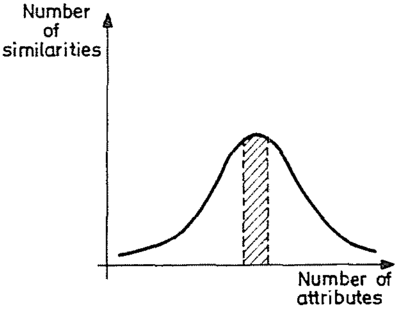

Fig. 7

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References

1. YOSHIKAWA, H.–TOMIYAMA, T.: Extended General Design Theory. Stichting Mathematisch Centrum, Amsterdam, 1986.
2. AXELROD, C. W.: Computer Productivity. Wiley and Sons, 1982.
3. RICH, E.: Artificial Intelligence. McGraw Hill Company, 1983.

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