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NUMERICAL REMARKS ON THE MULTIPLE-VALUED DECISION STRUCTURES TO CAD OF MECHANICAL SYSTEMS

Abstract. Generation of structures of the designed system. Minimization of multiple-valued logical functions. Decision tables for CAD.

1. Introduction

In the case of automation of technical system design typical functions, i.e. purposes fulfilled by the designed system, should be taken into consideration. Each function may have any number of standard realizations. Hence, many variants should be analysed according to the relation "each realization of the first purpose and each realization of the second purpose...and each realization of the last purpose". Thus a set of theoretical versions of the designed system is obtained and it should be structurally estimated and next reduced in consideration of its technical realizability in a way of a physical model. This procedure is at the stage of initial design and it is called "generation of structures of the designed system". At the stage of detailed design analytic evaluation of realizable solutions is done. These realizable solutions were obtained at the stage of initial design using problems of value analysis for the criterial set including weight information on reliability, number of elements, static and dynamic properties, weight, overall dimensions, servicing facility etc. Such qualitative analysis leads to the stage of modifying the realizable solutions which have a suitable value of usability function with use of catalogue information on permissible elements according to the arranged parameters which can be updated.

Hitherto structural methods of design do not use problems of mathematical logic which, after a suitable notation, make it possible to introduce CAD of technical systems at various stages. There are, however, many problems of design methodology which can be

solved with formal exact methods - not only heuristic,often decep - tive methods.

2. Faults of classical structure generating and advantages of modified generation of structures

The paper includes generalization of the Quine-Mc Cluskey minimization algorithm of two-valued and multiple-valued logical functions for CAD [2, 4, 5, 6].

It should be emphasised that the optimum solution expressed by the minimum alternate form (i.e. classical) and the optimum solution written in a minimum coplex form (i.e. structurally) are, on the basis of mathematical logic theory, equivalent in the abstract sense to a primary logic expression, describing a set of realizable versions of the designed system. Of course the primary logic expression describes the set of realizable versions of the designed system only quantitatively; the qualitative description is not full because it does not include importance of functions (aims) of the designed system and minimum of decisions of realizations of these functions.

The above faults of results of the preliminary designing should be eliminated by suitable ranking particular functions (i.e. aims) and, at the same time, by indirect ranking particular realizations. Such a modification gives some instructions for the stage of detailed designing in form of a decisive description of the rank of particular functions. Thus, it results that the detailed designing cannot be started with any function or realization.

3. Decision structures

Both two- and multiple-valued decisive tables [1, 7] can be reduced with the Quine - Mc Cluskey algorithm of minimization of logical functions. If the algorithm is directly applied,qualitative structural problems connected with a priority of suitable conditions in designing process are not taken into consideration, although all transformations are logically equivalent and give minimum of the structure. The priority of conditions is determined by introduction of interdependence in the set of independent variables and it leads to realizable solutions, dependent on a sequence of variables. Owing such a treatment of the problem it is possible to introduce problems of artificial intelligence for CAD of machine systems with suitable theorems of mathematical logics, theory of algorithms and automata theory. In particular, at the stage of preliminary designing for qualitative classification of realizable solutions the following theorem is valid: If α^* is a decisive number describing priority of multiple-valued decisive structure, then $\alpha^* = R + m_i^*$, wher R is a remainder of strong consensus according to the i^{-1} Quine - Mc Cluskey algorithm and m_i^* - generalized complement of ith variable which is m_i - valued i.e. $m_1 \ \ldots \ (M - m_i) \ \ldots \ m_n$, where $M = \max(m_1, \ldots, m_n)$. Next generalizations can be introduced,too.

If the vectors $(1,1,2,1)$, $(3,1,1,1)$, $(2,2,1,1)$ denote realizable structures obtained as a result from a suitable morphological table, then functional order $3_{2_{1_4}}$ is better than $4_{3_{1_2}}$, but worse than $3_{1_{2_4}}$ with the assumption that a digit in a higher position denotes a less important function.

It can be, however, proved that a basic structural part of the designed system will not change if the above vectors are written as $(1,1,2)$, $(3,1,1)$, $(2,2,1)$ and denote realizable structures as a result of a primary morphological table. But now it appears that a functional order 3_{2_1} is worse than 2_{1_3} but of the same quality as 2_{3_1} with the assumption that a digit in a higher position in these symbols denotes a less important function.

5. Conclusions

There is a possibility of introduction of further generalizations considering - among others - structural and computational complexity.

6. Example

A detailed example of structural designing of a machine system with use of multiple - valued decisions is presented in [3].

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NUMERYCZNE UWAGI O WIELOWARTOŚCIOWYCH STRUKTURACH DECYZYJNYCH W CAD UKŁADÓW MASZYNOWYCH

S t r e s z c z e n i e

Generowanie struktur projektowanego układu. Minimalizacja wielowartościowych funkcji logicznych. Tablice decyzyjne w komputerowym wspomaganiu procesu projektowania.

ВЫЧИСЛИТЕЛЬНЫЕ ЗАМЕЧАНИЯ О МНОГОЗНАЧНЫХ СТРУКТУРАХ РЕШЕНИЙ В АВТОМАТИЗАЦИИ ПРОЕКТИРОВАНИЯ МЕХАНИЧЕСКИХ СИСТЕМ

Р э з ю м э

Формирование структур проектированной системы. Минимизация многозначных логических функций. Таблицы решений в автоматизации проектирования.

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