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Algorithmisation of design features selection of ordered construction families

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Analysis and modelling

ABSTRACT

Purpose: The main reason for starting research concerning new methods of creating ordered families of construction was a need to substitute traditional method used to realize those processes by methods orientated on computer aiding.
Design/methodology/approach: Paper treats about development of algorithmic methods realizing γ assignation (which determines relations between parameters of the future technical feature and its design features) in the process of ordered families creating. The main tool of algorithmization is developed theory of constructional similarity, supported by neural networks application method.
Findings: The main achievements presented in this paper are developed theory of constructional similarity orientated on computer aiding and neural network application method, both used in designing process of new technical features. Moreover, both methods are highly susceptible to parametrisation.
Research limitations/implications: Analyzed methods develop algorithmisation of designing environment and support integration with the process of preparating the production. Intense research on the theory of technological similarity is being made nowadays.
Practical implications: Described methods were being developed on practical examples of creating the module systems of hydraulic cylinders used in mining, slag cars used in metallurgy and gears series of types. Nowadays the gripping devices series of types is being made.
Originality/value: Presented in the paper method of the constructional similarity, the algorithmic method and neural networks application method are basis of selection of design features in the process of ordered construction families (series of types and module systems of constructions) creating. All of these methods support intensive development of the types of technical features and affect on their competitive on the ready market.
Keywords: Constructional design; Series of types; Module system of construction; γ assignation

1. Introduction

The selection of elements dimension values is one of basic problems of ordered construction families creating. It is the most susceptible stage to algorithmisation and computer aiding.

In the process of the creating ordered construction family four group of transformation were distinguished [1,2,11]:

- α – the assignation requires to constructional solutions,
- β – the assignation constructional solutions to constructional forms of elements,
- γ – the assignation requires to values of element dimension,
- δ – the assignation requires to the number of ordered components of the construction family.

The γ assignation is the object of consideration in this paper.

Followed methods of selection of quantity design features are distinguished:

- the traditional method,
- the method of the constructional similarity,
- the algorithmic method,
- the neural networks application method.

2. Traditional method

Traditional method of selection of quantitative design features consists of the sequence of traditional, non-algorithmic designing initiated for matrix of needs. The selection of rules of dimensions basing on rules of γ assignation for every component of construction in order described by a graph of conjugation [1,2,5,7].

3. The theory of constructional similarity

The basis of creating ordered family of construction with use of construction similarity is a standard construction $ks_0\left\{y_{ol}^{e_j};(l=1,\ldots,lv_j)(j=1,\ldots,jz)\right\}$ with set of standard needs $\overline{X}_0\left\{x_{0a};(a=1,\ldots,az)\right\}$. On a base of standard construction and needs the families similar in geometrical form $ks_i\left\{y_{il}^{e_j};(l=1,\ldots,lv_j)(j=1,\ldots,jz)\right\}\in RK_n$ are being created in order of matrix of needs $\overline{X}_i^u\left\{x_{ia}^u;(i=1,\ldots,iz)(a=1,\ldots,az)\right\}$ with maintained identical relations of conjugations and relations of transformations. Values of dimensions are matched to normal numbers.

Standard construction is a construction verificated by practical and experimental methods and used once in a process of production. Product complied with this conjugation fills all set of criterions in the best possible way [3,4,5,6,11,12,13,14].

Standard construction for the sake of precision of computations of dimensions values should be represented by a centre of set of created family of constructions. Analysed method uses numbers of similarity:

- similarity of parameter $\varphi_{ia}^u=\dfrac{x_{ia}^u}{x_{0a}}$
- similarity of dimension $\varphi_{il}^{e_j}=\dfrac{y_{il}^{e_j}}{y_{0l}^{e_j}}$

There is a strict relation between digitization of characteristic features which generates sequence of parameters $\vec{X}_a^u\left(x_{1a}^u,\ldots,x_{ia}^u,\ldots,x_{iza}^u\right)$ and digizitation of variable dimension which generates sequence of dimension $\vec{Y}_l^{e_j}\left(y_{1l}^{e_j},\ldots,y_{il}^{e_j},\ldots,y_{izl}^{e_j}\right)$ [1,2,11,12,13,14].

Theory of constructional similarity rules the selection of design features maintaining relations and transformations in the new construction from standard construction. Moreover the set of variationality of constructions should be optimal.

Relations may be represented by set of mathematical functions which describe physical phenomenons, stereomechanical states (critical stress) and simple states (geometrical relations between dimensions of conjugate elements).

Fulfilment of theory of constructional similarity within stereomechanical states is called Cauchy problem [6]. In mechanical engineering Cauchy problem rules maintenance of the level of effort of material, strain and safety number in every new construction.

4. Algorithmic method

The algorithmic method [1,2,11,12,13,14] execute γ assignation to all vector parameters $\overline{X_i^u};(i=1,iz)$ according to the sequence and connections created on the basic of the conjugation relation graph $G\left\langle\prod_{rw}^{te_j}\right\rangle$ [3,4,5,15] with the application of operators [O]:

$$y_{m1}^{e_j}\left(j=1,jz\right)=\left[O\right]*x_{ia}^u\text{, dla m = I} \tag{1}$$

Operators transform the parameters values matrix x_{ia}^u to set of variable dimensions values matrix $y_{m1}^{e_j};\left(l=1,lv_j\right)$ for all construction elements from the construction family descripted by typical construction forms $\prod_{rw}^{te_j};\left(j=1,jz\right)$. A model of assignation creation presents Fig. 1.

There are distinguished following operators [1,2]:

- geometrical operators O_G,
- strength operators O_W,
- selected elements operators O_D,
- manufacturing operators O_P,
- constructional similarity operators O_C,
- conjugated dimensions operators O_S.

The selection of proper operators is related to the realisation of the construction process and dependents on ordered construction family creators.

A model of application and next preparation of the algorithm and graphical program is presented in Fig. 2. Set of all applied operators in the conjugation relation graph in the generalised form was presented in Fig. 2a. Complexity in creation of γ assignation presented in Fig. 2a may be simplificated by the object oriented software. The software objectivity mainly boils to application of the repeating subprograms of the different grade of nesting. On the base of the conjugation relation graph and precised operators the algorithm and next analytical programs flexible fitting to the selected set of typical constructional solutions is created – Fig 2b.

Analytical programs can occur in form:

- individual with application of a programming language (FORTRAN, Delphi),
- connected with a graphical program (VisualLISP programming language in AutoCAD).

5. Neural networks application

The algorithm of the selection of quantity design features in the process of ordered construction family creating may applied to the neural network creation and education. This enable take maximal utilisation of created algorithms and affect on simplification of the selection of element dimension values. The expertly builded neural network after the introduction of learning algorithms and its training allows to obtain (according to introduced parameters of the technical feature) variable dimensions values of constructed elements with the minimal level of deviation and the relative short time [8,9,10,11].

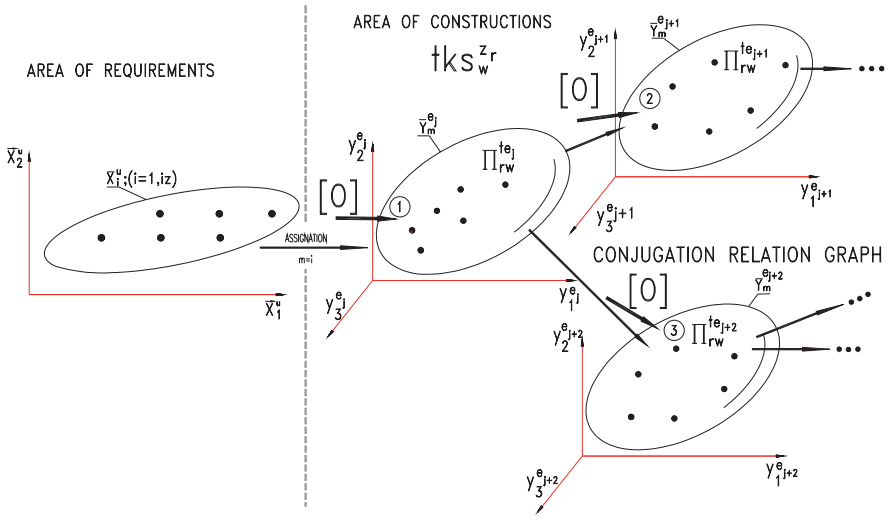

Fig. 1. A model of the algorithmic creation of an assignment γ

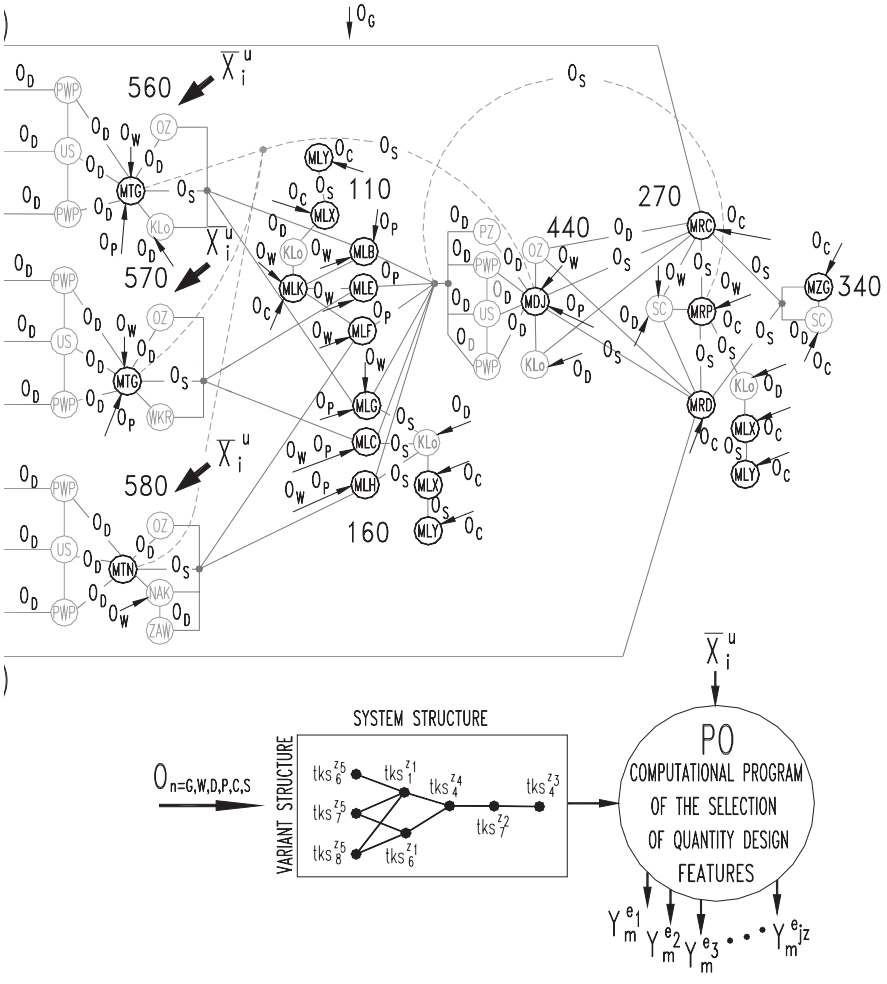

Fig. 2. A model of creation the computational program for the γ assignment

An example of application of neural network creating of the gears construction family, where the calculated number of analysed parameters extends traditional operations of designe

By application of the FEED FORWARD type of network of 3 – 17 – 17 –17– 14 topology, for 5600 training data and 1000 testing data after 5000 iterations output data of the deviation level 0.08 ÷ 0.98 % in relation to analogical traditional calculations were obtained.

6. Conclusions

For the reason of the dynamics developments of design techniques and computer aided methods it is important to devote major attention to methods considerations of flexible computer aiding rather than creation of ordered construct families.

Results obtained for the method of the selection of quantity design features with application of the neural networks method should be approximated and the same the algorithmic method of the selection of dimension values should be basic for creating ordered construction families.

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