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AN ALGORITHM OF COMPROMISE STRUCTURAL OPTIMISATION OF BAR STRUCTURES

1. Introduction

Authors' own research in applied unicriterial [1,2] and multicriterial optimisation of bar structures [3], and also an analysis of accessible bibliography on structural synthesis [4÷9] allows to present herein an attempt to define a general algorithm for proceeding in formulation of a structural optimisation problem.

A practical aspect of such an algorithm consists, in author's opinion, in enabling a designer a correct creation of a mathematical model of synthesis problems, independently of known mathematical methods employed to looking for a conditional extremum of function of several variables.

A proposed algorithm is not a ready-for-use tool for solving all the optimisation problems, but it constitutes an easy-to-expand theoretical basis. This basis should allow a designer to create a proper set of compromises on the way to construct a mathematical model of a specific optimisation problem.

The algorithm, presented in this paper, is constructed as a sequence of the one-after-another problem questions, on which the designer answers: *yes* or *no*, and a set of selections from the knowledge base consisting of the elements of an optimisation problem components. The order of making questions adopted by the authors in the algorithm is subjective, however it is supported by their experience, both in applied optimisation and in designing of structures like trusses or frames.

2. Algorithm of formulation of the mathematical model of optimisation problem

2.1. Assumptions

The authors accepted the following assumptions to define a category of currently considered optimisation problems:

a) as structural optimisation problems are considered that of searching for a conditional extremum of a several variable function,

b) it is assumed that one-branch structural design problems are, from the nature, unicriterial optimisation problems,

c) it is assumed that multi-branch structural design problems are multicriterial optimisation problems, as it
is natural,

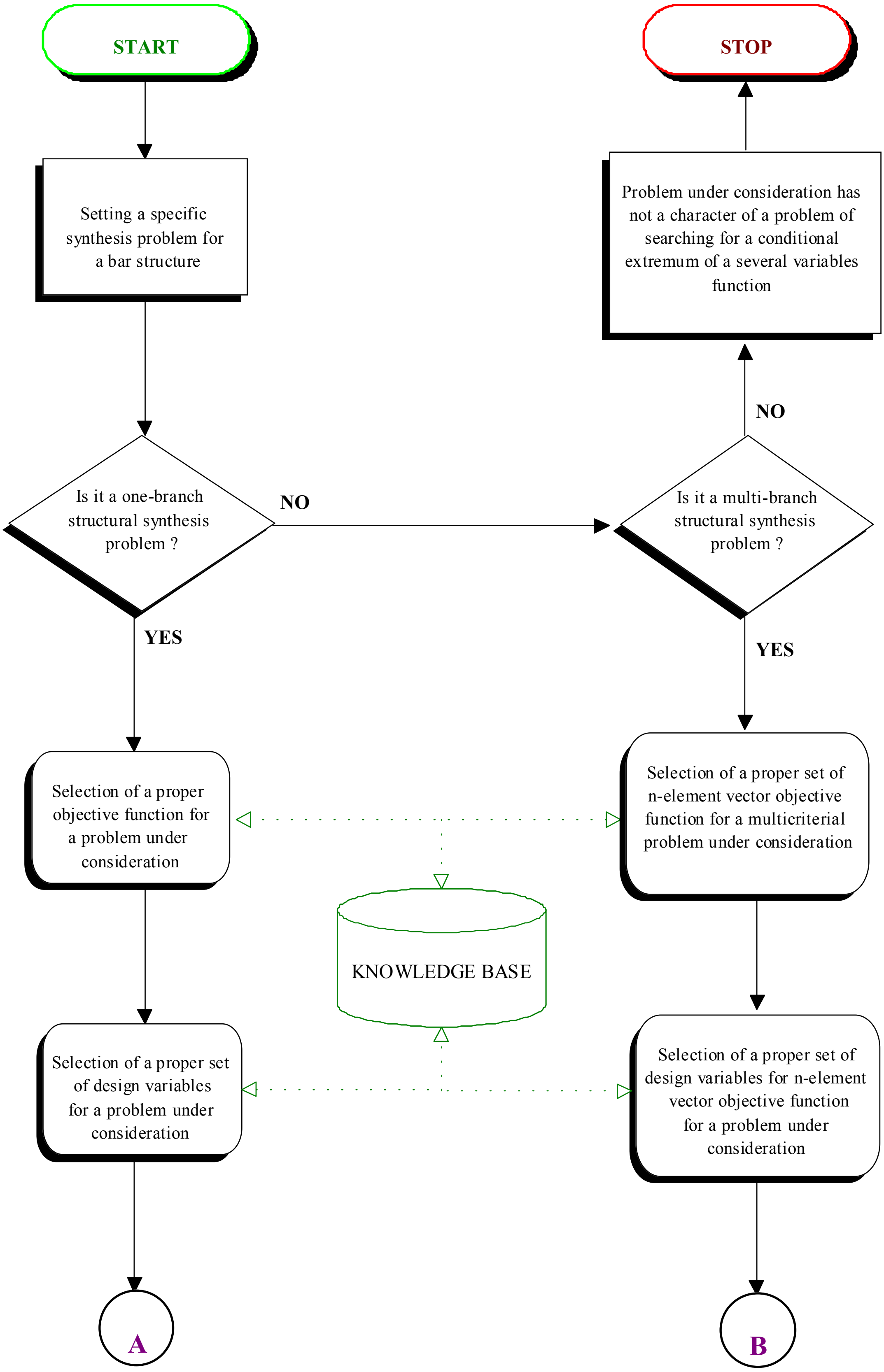
d) there is not excluded an existence of optimisation problems different that defined in **b)** and **c)**, however
they are not considered in this work,

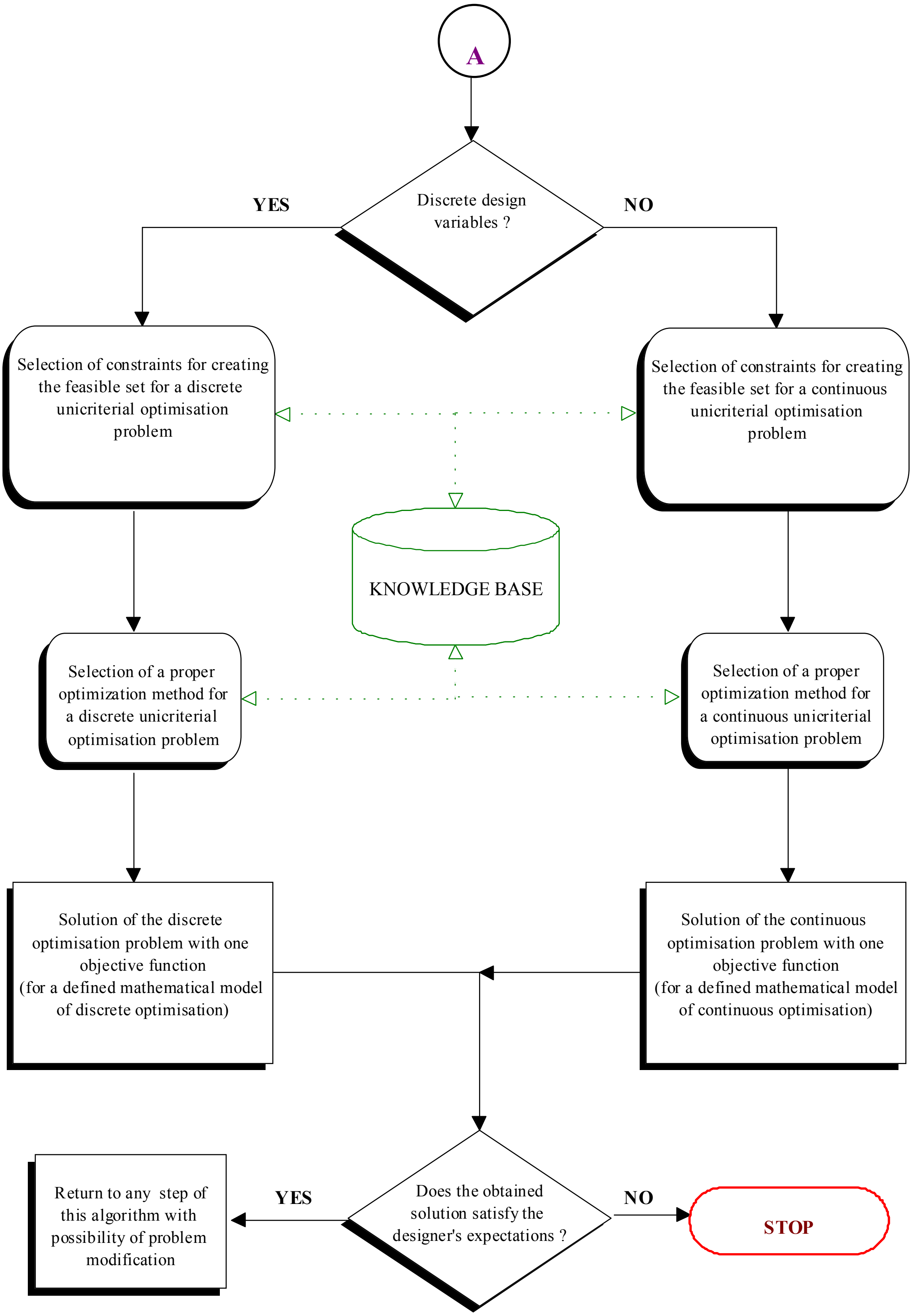
e) an implemented *knowledge base* consists of *problem bases*, grounded on existing knowledge in the field of the applied structural optimisation. Currently it is being developed and bringing up to date by the authors of this paper,

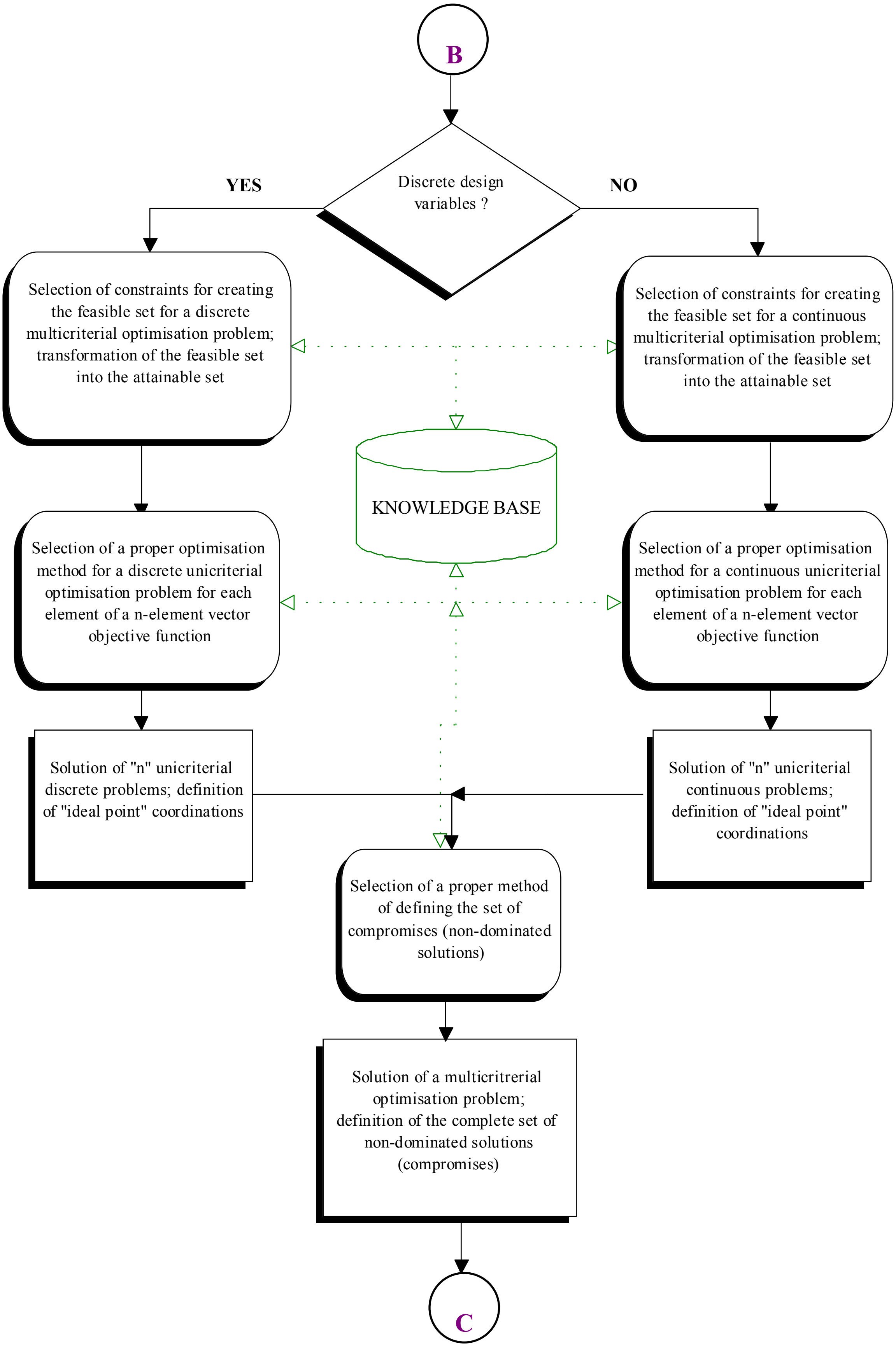
f) compromises considered by designer during the exploitation of the proposed algorithm are divided into

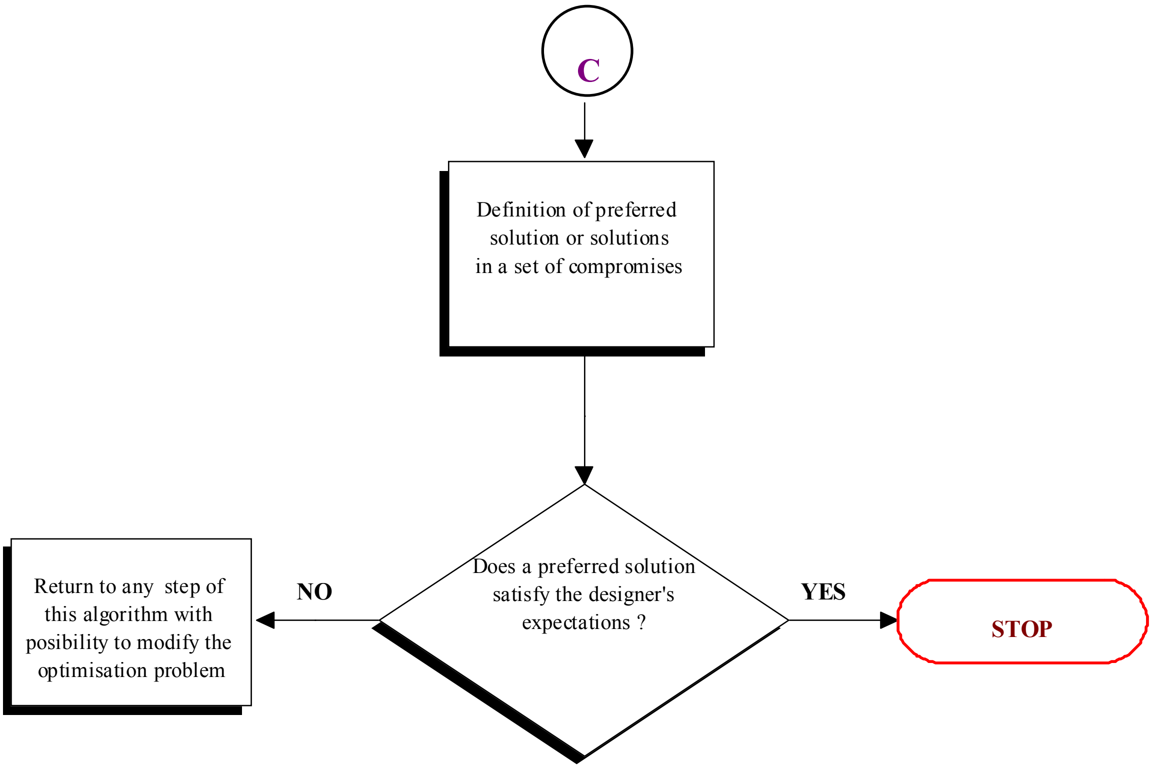
the simple ones (that of answers on problem questions), and the complex ones (that of selections of elements of the optimisation model from the data base).

2.2. Flow chart of the compromise optimisation algorithm


START
STOP
Setting a specific synthesis problem for a bar structure
Problem under consideration has not a character of a problem of searching for a conditional extremum of a several variables function
NO
Is it a one-branch structural synthesis problem ?
NO
Is it a multi-branch structural synthesis problem ?
YES
YES
Selection of a proper objective function for a problem under consideration
Selection of a proper set of n-element vector objective function for a multicriterial problem under consideration
KNOWLEDGE BASE
Selection of a proper set of design variables for a problem under consideration
Selection of a proper set of design variables for n-element vector objective function for a problem under consideration
A
B


A
Discrete design variables ?
YES
NO
Selection of constraints for creating the feasible set for a discrete unicriterial optimisation problem
Selection of constraints for creating the feasible set for a continuous unicriterial optimisation problem
KNOWLEDGE BASE
Selection of a proper optimization method for a discrete unicriterial optimisation problem
Selection of a proper optimization method for a continuous unicriterial optimisation problem
Solution of the discrete optimisation problem with one objective function (for a defined mathematical model of discrete optimisation)
Solution of the continuous optimisation problem with one objective function (for a defined mathematical model of continuous optimisation)
Return to any step of this algorithm with possibility of problem modification
YES
Does the obtained solution satisfy the designer's expectations ?
NO
STOP


B
Discrete design variables ?
YES
NO
Selection of constraints for creating the feasible set for a discrete multicriterial optimisation problem; transformation of the feasible set into the attainable set
Selection of constraints for creating the feasible set for a continuous multicriterial optimisation problem; transformation of the feasible set into the attainable set
KNOWLEDGE BASE
Selection of a proper optimisation method for a discrete unicriterial optimisation problem for each element of a n-element vector objective function
Selection of a proper optimisation method for a continuous unicriterial optimisation problem for each element of a n-element vector objective function
Solution of "n" unicriterial discrete problems; definition of "ideal point" coordinations
Solution of "n" unicriterial continuous problems; definition of "ideal point" coordinations
Selection of a proper method of defining the set of compromises (non-dominated solutions)
Solution of a multicritrerial optimisation problem; definition of the complete set of non-dominated solutions (compromises)
C



3. Conclusions

The algorithm of creating the mathematical model for a chosen class of structural synthesis problems presented in this paper is a simple tool dedicated for designers and structural engineers. It divides the optimisation problem into unicriterial (one-branch) problem or multicriterial (multi-branch) one. This division is introduced by the authors basing it on the analysis of optimisation bibliography and their own experience in the field of structural synthesis.

Selected compromises necessary to create the mathematical model of optimisation for a specific design problem are the essence of every human activity connected with decision making. A choice of any of them has a fundamental influence on a progress and a result of numerical calculations as the last part of the structural synthesis. A very important part of the presented algorithm is a *knowledge base*, containing ready-to-use detailed elements of the mathematical optimisation model (objective function, design variables, constraints, optimisation methods, etc.). Development and actualisation of such a knowledge data base will be a subject of the further author's investigation.

4. Bibliography

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