Application modeling multicomponent formulations and general-purpose functional food with a decision possible in the practice of optimization tasks in selected areas, such as chemical, mineral, vitamin content, energy value.

Developed based on the use of the model formulations design system is designed for professionals in the development of functional foods, including soft drinks. The algorithm of its operation could be used for other types of foods.

In developing the recipes FRR must be borne in mind that new combinations of raw ingredients, including functional food ingredients (FPI), could lead to some changes in the physiological properties exhibited by individual recipe ingredients. In this connection, newly developed formulation of each food item, particularly a functional purpose, should be chosen with the following requirements [5]:

- prediction of functional properties developed by FPP should be taking into account all inherent to its member DRF physico-chemical properties;
- at the design stage of PPP formulations should be avoided undue multicomponent arising when the FPI in the doubles;
- important to consider the additive, antagonistic or synergistic combination of the components of the chemical composition DRF each other and / or with other components of the formulation;
- it is necessary to comply with the dosing DRF based on daily physiological requirements for adults, taking into account gender, age, level of physical activity and children;
- FPP production technology must preserve the substance as much as possible to ensure that the function of the DRF.

CONCLUSION

Currently, development is considered in the design phase and the implementation of its individual components. It is assumed that in operation it will be launched in phases, as the willingness of its components and subsystems.

Potential customers: organizations involved in the design of food products, as well as education of the corresponding profile.

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A SOFTWARE COMPONENT FOR VISUAL MONITORING OF AN ACCEPTABILITY REGION DISCRETE APPROXIMATION

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Abstract— A software component for visualization of acceptability region's cross sections is considered in the scope of software complex for acceptability regions construction and utilization. The task of acceptability region exploration arises during an engineering system design and facilitates the exploration of admissible parameter variation area in order to provide parametric reliability. A discrete approximation of acceptability region may have significant errors, and in addition to facilities of quantitative error estimation tools for visual monitoring of the approximation quality are also required.

Keywords—acceptability region; reliability; parametric synthesis; computer-aided design.

INTRODUCTION

Under the term of acceptability region (AR) is understood as a multidimensional region in the space of system parameters space, where every point yields system responses which meet their specifications. The problem of AR characteristics determination arises during system design and in this paper is referred to as construction of AR or AR construction. This problem is more specific to designing of unique systems. Such systems may contain unique and non-standard custom components which may come without statistical information on their failures what makes probabilistic approach almost impossible. In the case when probabilistic approach to reliability estimation can be applied, deterministic methods of admissible parameter variation area analysis may provide additional information to improve decisions on parametric reliability.

One of the main problems which accompanies all the methods of AR construction is high dimension of system parameter space. Another problem is associated with the system's model form and consists in lack of explicit analytical expressions which map system parameters to its responses. The reason why the model is given implicitly is in model complexity and using of different CAD facilities which implement "black box" concept. Thus, the exploration of system parameter space can be implemented only point-wise.

In this work, a method of AR construction based on approximation of a multidimensional region with a discrete set of elementary boxes determined with nodes of a regular grid, and a multidimensional probing method [1]. This approach has methodological error occasioned by a grid step value. In the scope of the software complex for AR construction and utilization [2], additional software tool for AR approximation accuracy monitoring is required. The main problem of AR accuracy estimation consists in the fact that AR characteristics are unknown. Thus, AR approximation accuracy estimation is proposed on the basis of Monte-Carlo method, which has achievable accuracy without data redundancy.

It is essential to consider a problem of AR construction for understanding of AR approximation accuracy problem.

ACCEPTABILITY REGION CONSTRUCTION PROBLEM

For understanding of a context of AR construction task and its difficulties, let us consider parametric synthesis problem [1]. Let the system model is given in the form (1):

$$\mathbf{y} = \mathbf{y}(\mathbf{x}) . \tag{1}$$

The model (1) maps system parameters (resistors, capacitors, etc.) which are given with n-vector (2):

$$(x_1, x_2, ..., x_n)^T \tag{2}$$

to its performances (e.g., output voltage, gain, and so on) which are given with m-vector (3):

$$(y_1, y_2, ..., y_m)^T . \tag{3}$$

It is essential to the problem that the model (1) is supposed not only in explicit form. The model (1) can be in a form of simulation model which calculates outputs (3) for every given vector of inputs (2).

System responses (3) are usually bounded with specifications (4):

$$y_{i\min} \le y_i(\mathbf{x}) \le y_{i\max} , \forall i = 1,2,\dots,m , \tag{4}$$

which determine the system's binary state. The system is serviceable when all system responses meet their specifications in (4), and otherwise if at least one system response violates its specifications.

System parameters (2) are also bounded with tolerances (5):

$$x_{i\min} \le x_i \le x_{i\max} , \forall i = 1,2,\dots,n , \tag{5}$$

usually adjusted by manufacturer as a range of practically possible parameter value.

The problem of system's nominal parameters sizing, optimal in certain sense (parametric synthesis problem) by stochastic criterion requires multiple computations of system performances and checking of (4):

$$\mathbf{x}_{nom} = \arg\max P(y_{i\min} \le y_i(X(\mathbf{x}_{nom},t)) \le y_{i\max}), \forall i = 1,2,\dots,m, t \in [0,T] , \tag{6}$$

where $X(\mathbf{x}_{nom},t))$ is random process of system's parameters variation during operation period T. It is evident that obtaining of stochastic characteristics requires multiple simulations for system performances computation. According to the model complexity, this task may consume much computational resources and time.

On the other hand, we can see that system's performances specifications (4) determine an area inside system parameters space:

$$D_x = \{\mathbf{x} \in \mathbf{R}^n : y_{i\min} \le y_i(\mathbf{x}) \le y_{i\max}), \forall i = 1,2,..., m\} . \tag{7}$$

The set D_x, defined in (7), is called Acceptability Region (AR) in the system's parameter space. When AR characteristics are determined so membership of any vector $\mathbf{x}^* \in D_x$ can be checked a problem of parametric synthesis (6) can be stated as follows (8):

$$\mathbf{x}_{nom} = \arg\max P(X(\mathbf{x}_{nom}, t) \in D_x, t \in [0,T] . \quad (8)$$

It is evident that, in most cases, operation of a vector membership $\mathbf{x}^* \in D_x$ check requires less computational efforts than model simulation. Thus, obtaining AR characteristics can significantly accelerate computations of stochastic characteristics in (8). Nevertheless, the task of AR determination requires significant computational efforts and is considered as a separate procedure within system design process, based on high performance and parallel computations.

The task of AR construction for the model (1) with its performances specifications (4) and tolerances (5) consists in determination of AR characteristics (7). AR characteristics can be obtained through construction of a multidimensional area approximating AR.

ACCEPTABILITY REGION DISCRETE APPROXIMATION

Among various approaches to AR construction, in this work, a method of multidimensional area approximation with a discrete set of elementary hyper-parallelepipeds (boxes) determined with regular grid nodes and multidimensional probing method is considered. Let us describe only key features of the method in order to understand the AR approximation problem. The algorithm of AR discrete approximation in detail is described in work [1].

System parameters tolerances (5) define *n*-dimensional tolerance box which bounds an area of search and AR approximation. The search and construction area can be additionally narrowed with a circumscribed box which touches AR extreme points, determined using Monte-Carlo method [2]. Thus, the construction of AR approximation requires bounding box characteristics, given as a set of intervals (9):

$$B = \{ (x_{i\,\min}, x_{i\,\max}) , \forall i = 1,2,\ldots,n\} . \quad (9)$$

Every *i*-th interval in (9) is split equidistantly into q_i intervals with a step $h_i = (x_{i\,\max} - x_{i\,\min}) / q_i$. As the result, a multidimensional grid with the nodes determined with the interval borders intersections covers the area inside bounding box (9). This grid determine vertices of elementary boxes (EB). Every single EB is uniquely identified with a set of indices (10):

$$(k_1, k_2, ..., k_n), k_i = 1,2,..., q_i . \quad (10)$$

Using the indices (10) and grid step h_i boundary coordinates of corresponding EB can be calculated. In EB geometrical center, a "representative" point $\mathbf{x}_c(k_1, k_2, ..., k_n)$ is fixed. Its coordinates can be also obtained using the set of indices (10) and grid parameters (boundaries and step value). This "representative" point is used for calculation of system responses and their specifications (4) check. This procedure is defined in the following binary characteristic function (11):

$$\chi(k_1, k_2, ..., k_n) = \begin{cases} 1, \mathbf{y}_{\min} \le \mathbf{y}(\mathbf{x}_c(k_1, k_2, ..., k_n)) \le \mathbf{y}_{\max} \\ 0, otherwise \end{cases} . \quad (11)$$

The main feature of such AR approximation consists in supposition that the result of function (11) calculated for "representative" point $\mathbf{x}_c(k_1, k_2, ..., k_n)$ is applied to every point inside its corresponding EB identified with indices $(k_1, k_2, ..., k_n)$. The result of characteristic function (11) calculated for every EB is recorded in a set of binary membership indicators (12):

$$S = (s_1, s_2, ..., s_R), s_i \in \{0,1\} . \quad (12)$$

where $R = q_1 \cdot q_2 \cdot ... \cdot q_n$ is the amount of EB inside bounding box. The index of every single indicator in (12) is in one-to-one correspondence with its EB [1]. Thus, the binary function (11) defines a separation of the set of all EB B_g into non-overlapping subsets (13):

$$B_g = B_g^0 \cup B_g^1, B_g^0 \cap B_g^1 = \varnothing . \quad (13)$$

Subset B_g^1 represents desired AR approximation. Thus, the model of AR discrete approximation using a set of EB determined with a regular grid is defined in (14):

$$G_R = (n, B, Q, S) , \quad (14)$$

where *n* is the dimension of system's parameter space, *B* is the bounding box (9), $Q = (q_1, q_2, ..., q_n)$ is a vector containing grid intervals count for every parameter inside the bounding box, and S is a set of EB membership indicators (12) [2]. The example of AR discrete approximation for 2-dimensional parameter space is illustrated in Figure 1.

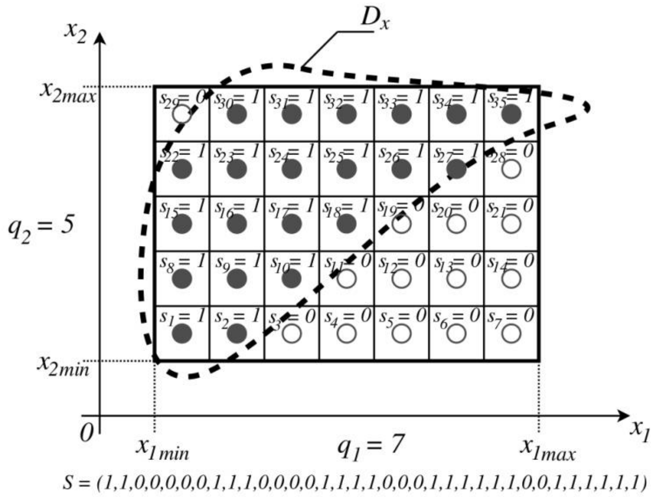


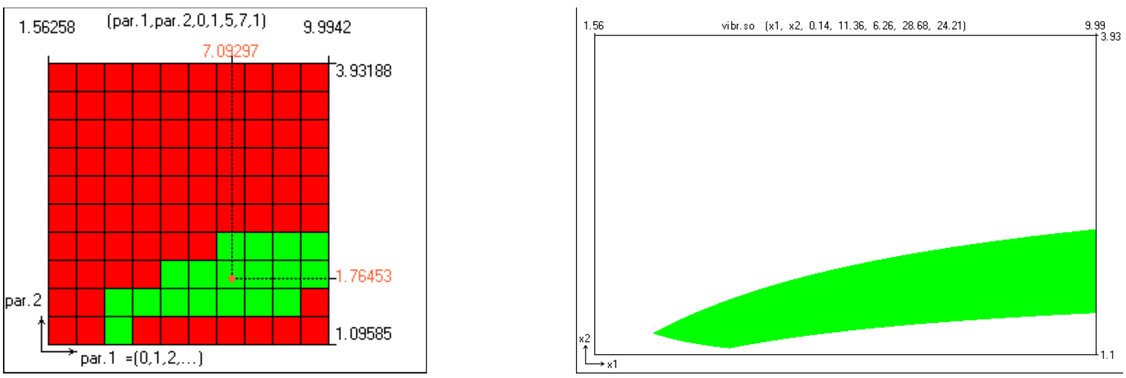
Fig.1 Acceptability region discrete approximation in 2-dimensional parameter space

A SOFTWARE COMPONENT FOR VISUAL MONITORING OF ACCEPTABILITY REGION APPROXIMATION ACCURACY

The problem of AR approximation accuracy consists in the fact that the characteristics of actual AR are unknown (except the cases when the model (1) is given explicitly). For the most of design tasks associated with optimal parameters sizing [3, 4], high accuracy of AR approximation is not necessary. The parts of AR near its border are of no interest opposing to the parts of AR distant to the border. For example (Figure 1), the bounding box determined with Monte-Carlo method cuts some insignificant AR parts. For the task of optimal parameters sizing, those AR parts have no significant influence. On the other hand, crude AR approximations, for example, with inscribed boxes or ellipsoids may omit such information on AR configuration like convexity or concavity, simple connectivity. Nevertheless, there are no recommendations on optimal grid step for the model (14) to achieve proper AR approximation accuracy.

Main requirement of AR approximation quality control consists in visual confirmation of correct detection of such characteristics as AR connectivity, convexity or concavity. AR approximation using coarse grid, in some cases, may represent AR as a multiply connected region, what may lead to incorrect solution of parameter sizing task. In order to visualize the accuracy of AR discrete approximation using the model (14), a Monte-Carlo method for visualizing 2-dimensional AR cross-sections is proposed.

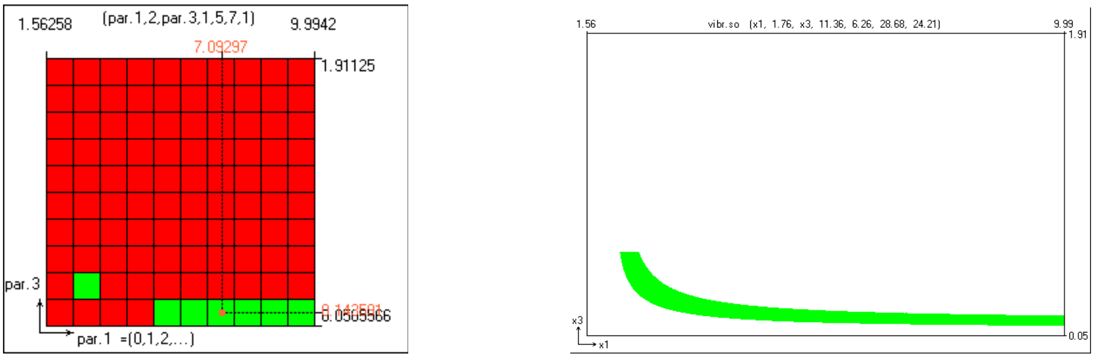
In Figure 2.a, a cross-section of AR approximation with a plane of the first and second parameter passing through optimal parameter vector. The same cross-section visualized with Monte-Carlo method is illustrated in Figure 2.b. It can be seen, that there is no significant errors in approximation of AR in this cross-section.



a) b)

Fig. 2. AR cross section: a) cross section of AR discrete approximation;
b) controlling AR section visualized with Monte-Carlo method.

Figure 3 illustrates incorrect AR approximation. As it can be seen in Fig.3.a, AR is is represented as two-connected region, but controlling cross section (Fig.3.b) done with Monte-Carlo shows us that the actual AR is too narrow for such grid step.



a) b)

Fig. 3. Incorrect AR approximation: a) cross section of AR discrete approximation;
b) controlling AR section visualized with Monte-Carlo method.

On the basis of controlling cross sections, a conclusion on accuracy of AR discrete approximation can be taken into account during design process. An engineer may decide to construct more accurate AR approximation or accept current one with certain adjustments.

A software component which visualizes controlling cross sections is an autonomous console application (uses standard input/output streams) within AR construction and utilization software complex. This component accepts the following parameters:

- A path and file name of a dynamically linked or shared library with system model (1);
- Fixed parameters indices and their values;
- Variation intervals – optional;
- Performance specifications (4) – optional;
- The amount of Monte-Carlo points;
- Output picture file name – optional;
- Output image width and height – optional;

The output of the application is an image file with cross-section visualized as illustrated in Fig.2.b and Fig.3.b.

CONCLUSION

AR discrete approximation on the basis of a regular grid and multidimensional probing method may give information on its configuration and allows to significantly reduce computational efforts in obtaining statistical characteristics of parametric drift, and apply geometric methods for optimal parameters sizing [4]. It is undeniable that AR discrete approximation requires significant computational efforts and storage resources. Therefore, this task is appropriate during design of unique and expensive technical systems. Apart from resources consuming, there is a methodological problem associated with AR approximation accuracy. It is not necessary to obtain high accuracy at AR border but it is very important to keep such characteristics of the region as convexity or concavity, connectivity. These characteristics of AR may shave significant influence on system's parameter sizing process. Therefore it is necessary to facilitate AR discrete approximation accuracy estimation with visualization tools. In this work a software component for visual monitoring of AR discrete approximation accuracy based on regions visualization with Monte-Carlo method is proposed.

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