Intellectual variation by penalty coefficients in the algorithm in constructing the contour of the enclosing structure of the heat network in the environment of the building CAD

Sorokin Oleg
Volga State University of Technology
Volgatech
Yoshkar-Ola, Russia
SorokinOlegVolgatech@yandex.ru

Sidorkina Irina
Volga State University of Technology
Volgatech
Yoshkar-Ola, Russia
igs592000@mail.ru

***Abstract*—The construction of a contour in the CAD of enclosing structures (ES) is one of the primary tasks at the stage of visualization of design procedures. Under the contour in this case we mean a closed polygon with the maximum possible coordinates for placement. The contour forms a field for the placement of elements and tracing, so the high-quality design of its boundaries allows better performance of these operations. In the CAD visualization subsystem OK, the contour is built on the basis of analysis of fuzzy information, by selecting penalty coefficients. The intellectual variation of penalties in constructing a contour allows us to introduce additional restrictions on its appearance and avoid problems of typical trace algorithms, such as: a large number of angles in the construction, non-optimal character of the problem zones, and others.**

***Keywords*—indefinite fuzzy information about the thermal circuit, engineering networks, enclosing the contour, intelligent algorithm tuning, automated design of the enclosing structure, penalty coefficients, optimization of the contour laying.**

I. Introduction

The introduction of penalty coefficients will avoid errors in the design of the circuit. The system of penalties, taking into account possible errors in the design process, is an easily customizable tool and allows to improve the design quality, due to the most accurate contour tracing and allowance for forbidden zones. The problem of constructing a contour is NP-complete and can not be solved by polynomial algorithms[1], since the adjustment is performed on the basis of varying the values of penalties depending on the type of situation, when tracing the contour. Each problem situation in the trace is given a certain initial weight, which then varies, depending on the conditions for constructing the contour. The change in the values of the penalty system will ensure the solution of the NP-complete tracing task of the circuit, since the initial data of the contour requirements do not allow accurate tracing by its classical algorithms.[2]

II. The relevance of the algorithm using penalty coefficients in CAD ES

At the stage of constructing the enclosing contour during the design of the engineering network design, a number of problems arise that need to be solved. This stage includes the tasks of: designing the technological environment, selecting the necessary design of the scheme, and arranging the heat equipment. In the course of solving each of these problems, it is necessary to choose the optimal solutions, and as a consequence, it is necessary to compare a lot of possible options and choose the best ones. These tasks, as a rule, are complex and to find the optimum it is expedient to implement the system, based on the use of intelligent algorithms, on the basis of penalty coefficients.[3] To solve the problem of thermal circuit tracing, it is necessary to develop an information system based on mathematical methods for optimization and models for describing existing objects. The result is the total heat flow, the information about which is used in the future to make decisions on the re-arrangement of heaters. The identification of situations in which the thermal circuit is visualized ultimately has only two options: the absence of problem zones (freezing zones) or their presence.The task of intelligent components with penalty coefficients on CAD thermal utilities, to provide the most optimal variant Layout, trace a connection point with the heat, so as to bring the course content of the page as possible to the user. The task of intelligent components with penalty coefficients on CAD thermal utilities, to provide the most optimal variant Layout, trace a connection point with the heat, so as to bring the course content of the page as possible to the user. The result of the algorithm is to visualize the nature of heat flow for a specific situation, taking into account the algorithm of identification of situations and decision-making.[4]

The result of the processing of the measuring information received from multiple sensors - recognition options situations subsequent trace heaters. Hierarchy overlay flows represents a fusion of the two fronts - warm from the heaters and the cold of the contour. The result is the total heat flow, which is then used for making decisions about repackaging heaters. Identifying situations thermal circuit eventually has only two options: no problem zones (zones freezing), or their availability.[5] Define the steps of an improved algorithm for identifying situations and making decisions using penalty coefficients:

- Step 1. Based on the generated a matrix of constraints using the linear programming technique, we form confidence intervals.
- Step 2. We form the constraint matrix for the contour, which determines the boundaries of the effect of the heat flux adjusted on the basis of penalty coefficients.
- Step 3. The matrix "code-solution" is checked for the existence of an adequate solution.
- Step 4. If a solution is found, then by the operation code we decide to visualize the heat flow in a certain way.
- Step 5. If no solution is found or if there are several solutions (fuzzy situation), then using the probability matrix is the solution with the maximum probability.
- Step 6. If there is no single-valued situation when the "code-solution" matrix is polled, the most appropriate frame sector is selected from the value memory by the binary relationship code from the value memory, where the most appropriate situation is then identified by the confidence test.

Thus, the function of choosing a new situation is realized by determining (by the code of binary operations) the most suitable sector of frames in the knowledge base, and also further improved on the basis of penalty coefficients.

III. Algorithm for tracing the enclosing contour in CAD ES using penalty coefficients

When managing penalty factors, uncertainties are also taken into account:

- The type of the thermal circuit. This type of information is fundamental, as it will have an effect on most others. In case of incompleteness of information on the type of the heat circuit, its prediction can be difficult, since the requirements for its construction are part of the terms of reference and are considered, as a rule, separately from the design system, as incoming input information. Inaccuracies of the type of the heat circuit can be corrected by forecasting means, including, in the case when mistakes are made in the construction at the initial design stage. In this case, a message will be issued indicating which construction rules are violated and a variant of their correction will be offered.
- The nature of the distribution of temperature. This information is the most voluminous and, as a rule, embedded in the database of the design system. Nevertheless, for different types of construction[6], with a strong influence of the external environment, the nature of the distribution of the temperature fields inside the structure can not be predetermined and requires the introduction of forecasting elements. An example can be situations where a lot of sources influence the outline of a building, including the external environment, timely calculations for the implementation of interactivity can be used on the basis of probability coefficients. In other words, when calculations of the temperature distribution inside the circuit take a long time, predicted values are used for instantaneous visualization, which allow us to evaluate the design quality at the initial stage, without the need for waiting for complex calculations.
- Mutual influence of heat flows. Information on the mutual influence of heat fluxes is necessary, first of all, to resolve the contradictions in the predicted data in those cases when several heat fluxes affect the same area of the contour at once. Accounting for the mutual influence of heat flows, for example, on heating elements is required when there are several heating elements in one closed loop.

The algorithm used is iterative and is used on the basis of local optimization. The first step of the algorithm is to create an initial approximation, which is included in the range of allowed values, based on the specified constraints in the trace algorithm.[3] In the case when many restrictions are added to the trace task, penalty functions can be selected in the target function, and the initial solution is outside the range of acceptable values. Penalties can be described by the formulas:

$$F'(x) = \Theta(x) + X0(x), \tag{1}$$

$$F(x) = \{ 0 \ , \ yzx = G \sum_{i=1}^{m} \lambda i(mi(x) - ci), \ yzx \notin G \tag{2}$$

where λ_i are penalty coefficients. According to these formulas, the last iteration of optimization is the minimal solution of the function $F(x)$, provided that it belongs to the admissible values $\omega \in G$. In this case, the introduction of penalty coefficients allows tracing the contour with the maximum accuracy, and also with the introduction of an additional unconditional optimization, criteria. It should also be noted that the use of the apparatus of penalty functions allows us to compare the values of the function $F(x)$ that do not belong to the admissible set G, and also in the case when all restrictions are not observed. Further optimization of the circuit can be expressed as:

$$X'' = arg_{x \in k}^{min} F(x) \tag{3}$$

Where k is the number of the row. This formula not allow to completely describe the process of obtaining the initial solution, in which some overlaps are not assigned to the main contour. To implement the initial solution, one k_0 value is entered into each row ki, which corresponds to the cancellation of the selection of the coordinate not belonging to the contour. In addition, it is necessary to take into account the limitations for the initial solution:

$$| \omega_i - \omega_{0i} |> 0,\ i \in (1, N) \quad (4)$$

Also, the function describing the penalty coefficients should be added:

$$F(x) = F'(x) + \sum_{i=1}^{N} \lambda_{i0} * \vartheta(\omega_i, \omega_{0i}) \quad (5)$$

The cycle of operation of the algorithm ends when a local minimum is reached at the N^{th} stage, or when a solution that satisfies the range of admissible values is obtained.[7]

Let's single out the main iterations of the algorithm for tracing the enclosing contour:

- Determination of the initial approximation ω_i
- Formation of the initial solution ω_0
- Going to the next iteration
- Check if the limit is reached on iterations of N if a transition is made to item 7
- Formation of a neighborhood of points in a series.
- Finding the minimum of the function $F(x)$
- If the value does not belong to the set G, go to step 3.
- Completion of the algorithm.

The first step defines the allowable range for all contour boundaries. In step 2, ω_0 is chosen as the initial approximation. Steps 3 and 4 implement the transition to the next optimization step, and also perform a check on the maximum number of iterations of N. Then, in Step 5, the initial solution for the next i-th step becomes the decision taken as locally optimal. At Step 6, a neighborhood of the permissible values for the i-th stage is formed. In Step 7, the reassignment is performed to determine the optimum relative to the neighborhood formed in Step 6. In the case where the solution is possible, the algorithm terminates, otherwise the next iteration is performed.

The task of reassigning a solution $O_i(\omega_i)$ is to determine the number of path paths[8] that can be deleted and rebuilt. If after the i stage, the resulting trace solution is not optimal, then for a certain set of connections j the definition of a new neighborhood oi (ω_i) is performed, which solves the problem of achieving the global optimum, by removing a part of the traces and then re-tracing. To obtain an acceptable solution based on fuzzy information, only pipelines $j = Q$ need to be rebuilt, for which some constraints (4) are not satisfied. Since condition (4) is not fulfilled at the initial stage of the construction, the minimum iteration step is usually chosen for the first iteration of the algorithm, and for each subsequent iteration an increase in step is required, since the number of traces satisfying the constraints grows. It should also be noted that the penalty coefficients on the initial iterations of the algorithm should also have a higher weight, since at the initial stage the number of traces satisfying condition (4) is minimal. The calculation of the penalty coefficients using the variation at the initial iterations of the algorithm will take the form:

$$F_m(x) = F'(x) + \sum_{i=1}^{N} \frac{N+z}{N} \lambda_{i0} * \vartheta(\omega_i, \omega_{0i}) \quad (6)$$

Where z is the number of traces that do not satisfy conditions (4)

The next step, to solve the task of reassignment, is based on the sequential assignment of traces, from the set of permissible ones and adding to the contour. The path is selected by assigning the corresponding trace to all permissible positions in the loop, and then fixing it in the most optimal position.

$$\omega_i' = arg\ min * F(\omega_{ij}) \quad (7)$$

ω_i' is the best position for the trace. $F(\omega_{ij})$ is the value of the criterion for assigning the i-th iteration to the contour ω_{ij}. The use of the reassignment method for tracing a contour makes it possible to find the optimum most accurately with respect to a certain region.

In the case when loop correction is performed on the basis of penalty coefficients, it is also necessary to additionally include new rules for logical inference in the knowledge base, which also require correction:

- Rule1. IF the coordinate of the heat flow distribution of the heater AND the coordinate of the heat flow of the utility network contour are equal to TH, calculate the resultant heat flux.
- Rule2. IF the coordinate of the heat flow of the circuit of the utility network has changed based on the coefficients of penalties, then we calculate the resulting heat flux.
- Rule3. IF the heat flow co-ordinate of the utility network contour was not recalculated automatically after correction based on penalty coefficients, then we calculate the resulting heat flux again.
- Rule 4. If the heat flux of layer N has a temperature less than $N + 1$, then an adjustment is necessary, provided that the check is performed that the contour has not been corrected.
- Rule 5. IF a region of the problem area is found, then build a minimal vector to the circuit of the utility networks to find the problem area.
- Rule 6. IF the nature of the contour is corrected, then rebuild the minimum vector.

Recognition of the situation is necessary for the possibility of setting temperature environment outside the contour, as well as granting councils in the case where the heat flow from the heater can heat the entire circuit. Elements of Learning Technologies Engineering Design of heating networks should be offered in this case, the best option arrangement, to perform communication with a heat tracing point and visualize the resulting heat flow from the heaters in the building loop.[9] The final stage of the work is to visualize the nature of heat flow for a specific situation, taking into account the algorithm of identification of situations and decision-making adaptive presentation. The goal of adaptive presentation technology is to adapt the content of a hypermedia page to the objectives, knowledge and other information stored in the user model. In a system with adaptive presentation, the pages are not static, but generated or assembled from pieces for each user. For example, expert users receive more detailed and in-depth information, while novices receive more additional explanation. Using fuzzy logic and methods for the synthesis and identification of situations in the electronic course, possible to apply the algorithm of identification of situations and decision-making, based on adaptive representation of information that takes into account all the possible outcomes in the data visualization. Using complex algorithms, the data will allow the most accurate visualization of heat flows in CAD interface ES, which will increase the accuracy of calculations and impact in the future on the quality of the layout of the heating elements in the design of the circuit.[10]

IV. Conclusion

An intelligent algorithm for constructing a contour in the CAD ES visualization subsystem of enclosing structures is proposed, based on penalty coefficients, which allows to optimally solve the NP-complete tracing problem even on the basis of fuzzy information. The algorithm is built on the basis of the principles of local optimization with the transition to the problem of unconditional optimization, which allows you to take the admissible values that are not included in the range of possible ones. The use of penalty coefficients allows to organize the optimization process, to form an optimum with respect to a certain set of data, and also to perform further optimization on the basis of reassignments.

References

[1] Sorokin O.L., Sidorkina I.G NP-zadacha balansirovki nagruzochnoi sposobnosti seti v SAPR [NP-task of balancing the load capacity of the network in the CAD] Otkrytye semanticheskie tekhnologii proektirovaniya intellektual'nykh sistem OSTIS-2015 [Open semantic technologies for the design of intellectual systems OSTIS-2015],2015, pp. 585-588.

[2] Vdovichenko I. Osobennosti sozdaniya bazy znanii standartnykh metodov provedeniya ekspertizy [Features of creating a knowledge base of standard techniques for conducting an examination] Zhurnal peredovykh tekhnologii [Journal of Advanced Technologies],2010, No. 2, vol.6. pp. 13-16.

[3] Sorokin O.L., Sidorkina I.G. Modul' opredeleniya statsionarnogo rezhima v SAPR naruzhnykh inzhenernykh setei [The module for determining the stationary mode in the CAD of external engineering networks] IS i IT-intellektual'naya CAD 2015 [IS & IT-Intellectual CAD 2015],2015 No.1. pp.70-75.

[4] Stetsko A.A. Sistema modelirovaniya i proektirovaniya trafika telekommunikatsionnykh setei v usloviyakh neopredelennosti [System for modeling and designing traffic of telecommunication networks in conditions of uncertainty] Informatika, sistemy iskusstvennogo intellekta i modelirovanie tekhnicheskikh sistem [Informatics, artificial intelligence systems and modeling of technical systems], 2006. No2. pp.109-111.

[5] Vashkevich N.P., Dubinin V.N. Struktura i funktsional'nye vozmozhnosti SAPR tokarnoi obrabotki [The structure and functionality of the CAD turning] Novye informatsionnye tekhnologii i sistemy [New information technologies and systems], 2004. p.143-144.

[6] Soloviev V.I. Metody optimal'nykh reshenii [Metody optimal'nykh reshenii] Praktikum uchebnoe posobie [Workshop manual], 2017. pp.50-55.

[7] Nomerchuk A.Y Metody upravleniya avtomatizirovannymi sistemami obrabotki dannykh na osnove nechetkoi logiki [Methods of automated data processing systems control based on fuzzy logic] Inzhenernyi SFU [Engineering SFU], 2013. pp 56-60

[8] Fokin K.F. Teplotekhnicheskii ograzhdayushchie chasti zdanii [Thermal engineering enclosing parts of the buildings] Izdatel'stvo Avok Press [Avoc- PRESS], 2006. p.256.

[9] Lebedev B.K. Intellektual'nye protsedury sinteza topologii SBIS [Intellectual procedures for the synthesis of VLSI topologies] Izdatel'stvo TRTU [TRTU publishing], 2003, pp.60–68.

[10] Kureichik V.V Osobennosti sredy analogovogo proektirovaniya VIRTUOSO [Features of the analog design environment VIRTUOSO] Intellektual'nye SAPR [Intelligent CAD], 2006. p. 105

ИНТЕЛЛЕКТУАЛЬНОЕ ВАРЬИРОВАНИЕ ШТРАФНЫМИ КОЭФФИЦИЕНТАМИ В АЛГОРИТМЕ ПРИ ПОСТРОЕНИИ КОНТУРА ОГРАЖДАЮЩЕЙ КОНСТРУКЦИИ ТЕПЛОВОЙ СЕТИ В СРЕДЕ СТРОИТЕЛЬНОЙ САПР

Сорокин О., Сидоркина И.

Аннотация - Построение контура в САПР ограждающих конструкций (ОК) является одной из первоочередных задач на этапе визуализации проектных процедур. Под контуром в данном случае понимается замкнутый многоугольник с максимально возможными координатами для размещения. Контур образует поле для размещения элементов и трассировки, поэтому качественное проектирование его границ позволяет более качественно выполнять данные операции. В подсистеме визуализации САПР ОК контур строится на основе анализа нечеткой информации, путем подбора штрафных коэффициентов. Интеллектуальное варьирование штрафов при построении контура позволить ввести дополнительные ограничения на его вид и избежать проблем типовых алгоритмов трассировки, таких как: большое количество углов при построении, неоптимальный характер проблемных зон и других.

Ключевые слова - неопределенная нечеткая информация о тепловом контуре, инженерные сети, ограждающий контур, интеллектуальная настройка алгоритма, автоматизированное проектирование ограждающей конструкции, штрафные коэффициенты, оптимизация прокладки контура.