Technical Solutions for Conceptual Design Search Automation

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Abstract: Existing search design automated systems during the conceptual design perform engineering solutions in the form of a sensing control system elements physical principle. The basis of the technical solutions have laid down a number of different approaches: formalized natural science, the scientific and technical effects description approach, based on an scientific and technical data ontology; energy-information model of chains, including the parametric structure charts method; structuring physical knowledge of designing and search design approach. However, despite the different approaches, used in the search automation, synthesis method using a decision tree are usually used. The article presents the results of a technical solutions search methods comparative analysis: synthesis method using a decision tree, traversal of graph in width, traversal of the graph in depth. Chosen information supports environment of the proposed methods for the automated search design systems. Shown the impact of the graph traversal methods applying in the specified environment, as a result, increases the effectiveness of automated technical solutions at the design stage.

Key words: Automated search design systems · Technical solution · The physical operation principle · Sensors · Search methods

INTRODUCTION

The existing, at present, the growth of labor productivity, scientific - technical progress acceleration, require sensor equipment developers to create, in the short term, new physical action principles(PAP) of control systems sensing elements at the best world standards level [1, 2]. This problem solution is largely determined by how well the developer will be provided with new tools, augmenting his intellectual capabilities to automate the information processing and technical solutions at the stage of conceptual design.

The analysis of existing CAD / CAM / CAE-systems, showed that within the modern automated systems there are tools, powerful enough to solve the PAP finding problem [3,4]. It is defined by a high level of scientific and technical knowledge formalization in a given subject area, where sensed elements PAP traditionally characterized by a parametric scheme of the linear structure with the given input and output, while the input value of each effect in the scheme must be equal to the output value of the previous effect [5, 6]. PAP search consists in removing from the database the parameter block diagrams options with specified input and output values. Diagrams of the physical - technical effects, in which the last output value is not the same as the output value, are not variants of search design and are excluded from consideration. The technical solution is selected from a set of received PAP options that meet the designer requirements.

One of the finding technical solutions methods, implemented in the automated systems, is a method for constructing a decision tree as a directed graph, where the root node takes the input PAP value. Then, with the help of physical and technical effects, child nodes are generated, which correspond to the output values of the selected effects. [7] Construction of the decision tree is over when you can not find the physical - technical effects to the node.

Problem Statement: With the implementation of PAP-sensitive elements search methods and the search algorithm, using a decision tree, only one way is remembered - in which the process go. However, with the
growth number of physical-technical effects in the chain, graph begins to rise due to the increase of vertices and the connections between them, therefore, the complexity of computational procedures increases dramatically, and as a result, in several times increases the algorithm running time.

Therefore there is a need to implement the control systems PAP-sensitive elements automated search in the most efficient manner.

**Methods and Study Results:** Posed problem is divided into two sub-problems: identifying the most efficient method of search mechanism and its implementation in automated systems.

Let us compare the PAP search methods: construct a decision tree, traversal on the graph in depth and width.

Let the graph G is given a set of vertices V (set of physics - technical effects), where \( v \in E \) - the root node (basic physics - technical effect in the block diagram), the set of arcs - E (possible effects connections), \( \Gamma(w,-) \) - a list of the vertex \( w \in V \) descendants.

Decision tree is a PAP options description, which contains information about all of physics - technical effects, with respect to the obtained solutions. When looking for technical solutions we use a decision tree with a queue "QUEUE" (Fig. 1).

When looking for technical solutions we use graph \( v \in V \) traversal in depth, some vertex \( G = \{V,E\} \) is fixed. Next, determine the vertex \( u \in V \), connected with the vertex \( v \in V \) adjacency relationship and consider it. The process is iterative in nature: at the next step vertex \( q \in V \) is considered. If there are no vertexes, adjacent to it, then back out of the vertex \( q \in V \) to the previous vertex. Eliminate duplication of the traversed top, for which we introduce the label \( NEW[V]=1*TRUE \); in the queue we enter vertices with the label "TRUE", which is changing to the label "FALSE" and use the procedure "WALK" (Fig. 2).

The block diagram (Fig. 3) shows the recursive procedure "WALK".

Finding solutions to the graph \( G = \{V,E\} \) traversal in width assumes to consider all the vertices from root \( v_o \), associated with the current.

The principle of selecting the next vertex consists in choosing one, which was previously considered. For the implementation of this principle requires a data structure "QUEUE", which corresponds to the block diagram (Fig. 4) with the initial

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\( \text{used} \) \( \text{queue} \) \( \text{while} \) \( \text{queue} \) \( \text{is} \) \( \text{not} \) \( \text{empty} \) \( \text{do} \) \( \text{for} \) \( \text{each} \) \( \text{vertex} \) \( \text{do} \) \( \text{if} \) \( \text{vertex} \) \( \text{is} \) \( \text{new} \) \( \text{then} \) \( \text{enqueue} \) \( \text{vertex} \) \( \text{else} \) \( \text{enqueue} \) \( \text{vertex} \) \( \text{false} \) \( \text{with} \) \( \text{while} \) \( \text{queue} \) \( \text{is} \) \( \text{not} \) \( \text{empty} \) \( \text{do} \) \( \text{for} \) \( \text{each} \) \( \text{vertex} \) \( \text{do} \) \( \text{if} \) \( \text{vertex} \) \( \text{is} \) \( \text{new} \) \( \text{then} \) \( \text{enqueue} \) \( \text{vertex} \) \( \text{false} \) \( \text{with} \) \( \text{while} \) \( \text{queue} \) \( \text{is} \) \( \text{not} \) \( \text{empty} \) \( \text{do} \) \( \text{for} \) \( \text{each} \) \( \text{vertex} \) \( \text{do} \) \( \text{if} \) \( \text{vertex} \) \( \text{is} \) \( \text{new} \) \( \text{then} \) \( \text{enqueue} \) \( \text{vertex} \) \( \text{false} \) \( \text{with} \)
Table 1: The results of approaches to model database comparison

<table>
<thead>
<tr>
<th>Database Model</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1 Graph-oriented model | - A storage that uses graphs knowledge for the formation of the internal structure, wherein the data structure is represented in a tree;  
  - Represented by different databases languages;  
  - Database mathematical platform is graph theory, which allows to operate with network data with links, "many - to - many" |
| 2 Object-oriented model | - Allows you to select the following levels of simulation objects: micro-levels (structural) and macro-levels (functional).  
  - On the first level complex objects are considered, used to identify the objects themselves;  
  - On the second level data items are considered, and the connection used to identify the types of objects: "belongs to the class" / "is an attribute" |
| 3 The relation model | - Initial information and discovered solutions are stored in relational tables, which can not be read completely into computers memory;  
  - The own set of operative memory buffers is supported, that is, when referring to any element of data is not an immediate exchange with external memory |

Table 2: Results of the DBMS speed comparison

<table>
<thead>
<tr>
<th>DBMS</th>
<th>The speed of the test, s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Clarion for Windows</td>
<td>13</td>
</tr>
<tr>
<td>MS FoxPro for Windows</td>
<td>11</td>
</tr>
<tr>
<td>MS Visual FoxPro</td>
<td>6</td>
</tr>
<tr>
<td>MS Access</td>
<td>6</td>
</tr>
<tr>
<td>dBASE for Windows</td>
<td>15</td>
</tr>
<tr>
<td>Paradox for Windows</td>
<td>11</td>
</tr>
</tbody>
</table>

Object-oriented databases are relatively new, modern systems like Objectivity, Poet, Versant have certain disadvantages when using them, and, unlike the graph-oriented or relational model, the database theory mathematical platform is not sufficiently developed.

Currently, the most used is the relational database model, which is supported by large packets: Oracle, Sybase, Informix, Ingres, and Gupta, as well as desktop packages: DBaseIV, Access, FoxPro, Alpha4 è Paradox. Relational model mathematical platform is based on relational algebra and calculus, which in turn are the basis of SQL - query language and ODBC - extension that allows them to connect the user interface in a client / server multi-layer applications.

Therefore, for the automation of technical solutions RDBMS was chosen. However, the successful automated system operation requires such a DBMS in which the most significant advantage is the speed of data retrieval and the existence of technology to optimize access to the database as a quick search on the index tags.

One of the most common indexes with high performance is the structure of the B-tree, the advantage of which is the possibility of a balanced values insertion or deletion. SQL-queries and search index compression can reduce the time required to perform technical solutions in accordance with the restrictions criteria.

To compare the speed of the most popular database management systems and the choice of software on this criterion for an effective application tests were performed, similar to a set of ASAP benchmarks [9]: using the DBMS listed in Table 2 [9, 10].

According to tests, operations on the table contents with the passports of physical and technical effects and plenty of options for PAP were carried out:

- Query on one field - is designed to select the combination of physical and technical effects that make up an invention scheme (Fig. 5).
- A set of fields query - used for the implementation of the PAP search algorithm (Fig. 6).
- Search for a bunch of fields - is effective for PAP search while forming the effects chains in case of synthesis limitation criterion choice, consist in prohibition on the repeatability of both the effects and the chain values (Fig. 7).
- Selecting a variety of PAP options and ordering them in places. Filter installation is used to display a subset of the best solutions (Fig. 8).

As can be seen from Table 1 and graph in Figure 9, which shows the results of the basic tests performed, Visual FoxPro on a whole range of these indicators has a leading position among the most popular desktop DBMS. This is due to the presence in the product Rushmore optimization technology.
SELECT Pat_fle *, Paten.pnumber, Paten.viname, Paten.pss;
FROM bazafe.pat_fle, bazafe/paten, bazafe/pss;
WHERE Pat_fle.pnumber=Paten.pnumber = .T. AND Pat_fle.pnumber =

?prm1

Fig. 5: Query on one field fragment

SELECT Paten.pnumber, Paten.kod_pr1, Paten.kod_vel1, Paten.kod_pr2,
Paten.kod_vel2, Paten.diaazon1, Paten.diaazon2 FROM bazafe/pss WHERE
NOT;
(ALTRIM(STR(Paten.kod_pr1))+" +ALTRIM(STR(Paten.kod_vel1)) ==
?par_p1);
AND NOT;
(ALTRIM(STR(Paten.kod_pr2))+" +ALTRIM(STR(Paten.kod_vel2)) ==
?par_p2)

Fig. 6: A set of fields query fragment

value1=STR(kod_pr1)+STR(kod_vel1)
SEEK value1 ORDER TAG prir_vel_in_out

Fig. 7: A set of fields search fragment

SELECT Rezult.numers;
RIGHT(STR(Rezult.mesto),8)+" | "+Rezult.shortnames, Rezult.mesto,
Rezult.senses, Rezult.prices, Rezult.reils, ..., Rezult.diaazon1,
Rezult.diaazon2;
FROM bazafe/rezult ORDER BY Rezult.mesto
SET FILTER TO REGNO(j)<=100

Fig. 8: Filter installation fragment

Fig. 9. The diagram showing the test results

The performance and availability of all requirements for a modern relational database management system, for information support for the technical solutions search during the conceptual design automated system, the FoxPro packet has been chosen.

To convert the knowledge of physical and technical effects in the tables and relationships, entity-relationship diagram as the logical abstraction of the real data and the created base structure was built. Considering rules for obtaining a relational schema of the ER-model and
the principles of database normalization, using the CASE-tool technology, an abstract model is converted into a real system tables and relationships.

To form the data on the effects of physical and technical inventions and sensor equipment in the form of graphical relational schema we used tools for database design XCase (product of Resolution, Ltd), as it is integrated into Visual FoxPro, automates all stages of the database design phase; when modifying a relational scheme, changing the attributes of one object is automatically propagated to the foreign key of another object, related to link. As a result of generation, we received a real system tables and the relationships between them. Figure 10 shows a fragment of the relational schema.

When designing the database structure, analysis of the entity "Inventions" key attributes functional dependence has led to the formation of two tables: "Invention descriptions" that contains the primary key of "invention ID", and associated by the "many-to-one" link with table "physical and technical effects, the parametric structural components of the inventions scheme", which has one foreign key "Identifier of physical and technical effects", which allows to uniquely identify the record.

To support mechanism to ensure referential integrity of the database with Xcase tools, triggers of deletion, addition and update were created to help in the update (removal) of the primary key fields values in tables' values chain "and "Physical nature of the chain" is automatically cascade update (erase) all relevant values in the tables "PTE passports" and "Invention descriptions". Trigger to insert checks if the record to add has foreign key fields in the child tables "PTE passports", "invention descriptions" values that are referenced in the parent tables' values chain "," Physical nature of the chain," and, in the absence of appropriate records, does not allow to introduce a new line, and thus violate referential integrity rules.

The interface form of the database is implemented (Figure 11).
Table 3: Search results for the PAP-sensitive elements options

<table>
<thead>
<tr>
<th>Number of PTE in the chain</th>
<th>Synthesis time (sec.)</th>
<th>Number of generated options</th>
<th>Number of obtained solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2</td>
<td>&lt;1</td>
<td>189</td>
<td>11</td>
</tr>
<tr>
<td>≤ 3</td>
<td>&lt;1</td>
<td>1130</td>
<td>88</td>
</tr>
<tr>
<td>≤ 4</td>
<td>2</td>
<td>5471</td>
<td>404</td>
</tr>
<tr>
<td>≤ 5</td>
<td>9</td>
<td>21546</td>
<td>2003</td>
</tr>
<tr>
<td>≤ 6</td>
<td>35</td>
<td>64785</td>
<td>6456</td>
</tr>
<tr>
<td>≤ 7</td>
<td>131</td>
<td>163472</td>
<td>17105</td>
</tr>
<tr>
<td>≤ 8</td>
<td>501</td>
<td>357104</td>
<td>37555</td>
</tr>
</tbody>
</table>

Fig. 12: The dependence of the generated variants amount

Criteria for narrowing the search space were introduced [11, 12]: parameters for the selection of physical and technical effects involved in the search for PAP-sensitive elements and provide samples of the first hundred decisions [13].

RESULTS

Table 3 shows the results of control system PAP-sensitive elements automated search, provided on the basis of the graph in depth and width traversal methods. Descriptions of each of the 230 effects stored in passports of physical and technical effects and constitute a source table.

Let the input PAP value - the change in temperature (Ut), the output value is the mechanical movement (Qml). We restrict the search space of 2 - 8 physical and technical effects in parametric structural scheme and the inadmissibility of units duplication.

Table 3 shows the search results for the PAP-sensitive elements options.

It is evident, from the figure 12, the total dependency on the number of generated options from the number of physical and technical effects in the block diagram, however, the proportional increase in the search time does not occur cause of using the Rushmore - accessing data optimization techniques.

Comparing the parameters in table 3, it is obvious, that an increase of the synthesis time is 500 times (included chains, containing from two to eight physical-technical effects), the number of generated options increasing in more than 1880 times, and the amount of the solutions - 3400 times.

This experiment shows that the search for PAP-sensitive elements technical solutions at a conceptual design of an automated model-based relational knowledge organization can be effectively implemented by using a graph depth and width traversal algorithm.

CONCLUSION

Currently an automated system that implements methods of graph traversal when searching for PAP-sensitive elements is developed. The implementation of such a system has allowed, in the first, to combine the different PAP search methods, in - the second, to increase the technical solution options search automation efficiency, as well as to apply the developed system for exploratory technical objects design.
REFERENCES


