Research on Case Organization and Retrieval of Case and Rule Based Reasoning Approaches for Electric Power Engineering Design

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Abstract: Electrical engineering design is a weak-theory field, in which a great deal of domain knowledge is not extracted yet. Although CBR technique can perfectly simulate expert's thinking process such as association, instinct, analogy, learning and recollection, it appears to be farfetched, unexplainable and unsystematic during its reasoning procedure because of its lack of deduce ability. In this paper the authors present case and rule based reasoning(CRBR) approach and bring forward a retrieving technique in the process of CRB and an organizing method of CRBR system for electric engineering design. The goal of the methods is to accomplish the whole tasks from scheme design to construction design.

Keywords: electric power system, engineering design, case based reasoning, rule based reasoning, case retrieval and organization

I. INTRODUCTION

CBR is based on human's cognizance procedure. The clou of a CBR system is to search its case memory for an existing case that matches the input specification, and then reason on the basis of previous successful cases similar to our input situation, rather than tackle the whole design work from the beginning.

So a representative procedure of CBR can be summed up as that:

- Retrieve the most similar past cases that is relevant to the input situation
- Adapt the selected cases to meet the needs of current situation.
- Sort the new cases into design database in the light of certain learning policy.

Therefore, CBR is an analogy reason methodology in deed and has been applied to many design fields such as mechanical, electronic, architecture etc.[1,2]. In brief, CBR technique can perfectly simulate expert's thinking process such as association, instinct, analogy, learning and recollection. However it appears to be farfetched, unexplainable and unsystematic in its reasoning procedure because of its lack of deduce ability. If introducing rule based reasoning (RBR) techniques having strong deduce ability when necessary, we would not only strengthen the system's flexibility and deduce ability, but reduce considerable works of retrieving cases and maintaining database. Thus it can be seen that combination of CBR and RBR techniques, i.e. Case and Rule Based Reasoning(CRBR) , is the optimal choice of the electrical engineering ICAD system.

To build CRBR system, some fundamental works have to be tackled first such as case representation, case strategy, organization of the characteristic roots, case adaptation and case learning and etc..

In this paper the authors bring forward a retrieving technique in the process of CRB and an organizing method of CRBR system for electric engineering design. The goal of methods is to accomplish the whole tasks from scheme design to construction design.

II. CASE ORGANIZING AND INDEXING STRATEGY

A CBR system derives its power from its ability to retrieve relevant cases quickly and accurately from its memory. Building a structure or process that will return the most appropriate case is the goal of the case's organization and retrieval process. Generally, each case possesses its features, with which retrieval strategy couldfind relevant cases. Ifthose features could represent a case sufficiently and necessarily, we call the case well defined. In current AI field, cases' organization and retrieval strategies usually fail into one of the three kinds: nearest neighbor, inductive, and knowledge-guided, or a combination of the three.

1). Nearest neighbor approach

Nearest neighbor approaches let the user retrieves cases based on a weighted sum of features in the input case that match cases in memory. This approach is a good one to use if the retrieval goal is not well defined or if few cases are available. As to electric engineering design, however, engineering cases and their features are numerous. Along with the different projects and different design phases, many features may emerge dynamically and be context dependent. Therefore, this kind of indexing approach can not be used exclusively in electric engineering designs .

2). Inductive approach

Inductive approaches can automatically, and objectively analyze the cases to determine the best features for distinguishing them. At the same time, design cases were organized into a hierarchical structure similar to discrimination net based on those best features (components of cases). Applying discriminating tree for retrieving, the system is good at tackle hierarchical problem. Nevertheless it

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needs the cases being well defined, and having reasonable quantity of cases to generate accurate discriminating features. However, electrical engineering design is an ill-structured problem, whose cases are generally ill-defined, so that it is difficult to applying inductive approaches into our work.

3). Knowledge-guided approach

Knowledge-based indexing approaches try to apply existing knowledge to each case in the library to determine which features are important for retrieving each case and use these features to organize and index cases. Having inducted the heuristic knowledge, we can reduce the number of retrieval features and narrow the searching scope. Meanwhile the case organization and retrieval are endowed with certain dynamic nature. This approach possesses high efficiencywhen a case base contains numerous features and each case does few. A part of subcases and their features in electric engineering design follows that.

Regarding the properties of electric engineering design, the authors propose the retrieving strategy combining neighbor and knowledge-guided approaches. The function the strategy is nothing but using the set of features and retrieving appropriate cases, so the relationship between cases and the set of features is pivotal. If the relationship can be represented with heuristic knowledge, then called those features as explicable features, otherwisecalled unexplainable features. In the engineering design, the knowledge-guided approaches can keep the high efficiency for the explicable features, while we have to use nearest-neighbor approaches to carry on the associative retrieval for the unexplainable features. As to the knowledge-guided method, we adopt the method of rule-based reasoning, which will be discussed in detail in the coming paper. We discuss the nearest-neighbor approaches in this paper, and bring forward the corresponding algorithm as follows.

III. NEAREST-NEIGHBOR ALGORITHM

Let the set of cases be $C=\{C_1,C_2,\ldots C_m\}$,and C_j be the j-th case in the case base. The set of features of C is $A=\{A_1,A_2,\ldots A_n\}$, A_i is the i-th feature. Then the associative matrix of feature with case is as follows:

$$P=\begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots\cdots & C_m \end{array} \\ \left(\begin{array}{cccc} p_{11} & p_{12} & \cdots\cdots & p_{1m} \\ p_{21} & p_{22} & \cdots\cdots & p_{2m} \\ p_{31} & p_{32} & \cdots\cdots & p_{3m} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ p_{n1} & p_{n2} & \cdots\cdots & p_{nm} \end{array}\right) \end{array} \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ \cdots \\ \cdots \\ A_n \end{array} \qquad (1)$$

Where p_{ij} is the value of the i-th feature A_i corresponding to the j-th case C_j. According to the degree the cases are influenced on, every feature is endowed with a suitable weight, and all the weights form the matrix W:

$$W=\{w_1,\ w_2,\ldots w_n\},\text{and } \sum_{i=1}^{n} w_i=1 \qquad (2)$$

The weight of general feature is confirmed by experienced experts. Letting all weights havethe same value is the simplest implementation.

Let the current case be C_0, and crresponding feature values are $\{p_1,\ p_2,\ldots p_n\}$. We can define its similarity (called case similarity) to the j-th case C_j as follows:

$$S(C_0,\ C_j)=\sum_{i=1}^{n} w_i \cdot s(p_i,\ p_{ij}) \qquad j=1,\ 2,\ \ldots m \qquad (3)$$

Where $s(p_i,\ p_{ij})$ called feature similarity is the similarity of feature p_i to p_{ij}, and could be calculated with the distance between them. Then $S(C_0,\ C_j)$ is obtained according to Eq.(3). However, we have to normalize the features value before calculating the similarity since the data types and their value-range are different.

In respect of numeric feature Ai, its value is generally limited with value interval, letting it be [a, b]. Then the distance between p_i and p_{ij} is $d=|p_i - p_{ij}|$,and its normalized value is obtained from:

$$d_* = \frac{|p_i - p_{ij}|}{b - a} \text{ and } 0 \le d_* \le 1 \qquad (4)$$

The similarity can be defined as:

$$s(p_i,\ p_{ij}) = \frac{1 - d_*}{1 + d_*} \text{ and } 0 \le s \le 1 \qquad (5)$$

Generally, the feature of character data Ai can be sorted into tow kinds: compatible features and incompatible features.

Each value of the compatible feature has a certain similarity with other values. For example, the distance from a load to a generator can be defined as {"short", "shorter", "medium", "longer", "long" }, and be quantized as { 0, 0.2, 0.5, 0.8, 1.0 } by engineering experience. The similarity of the value "short" with the value "shorter" should take a larger value than with the others (of course except "short" itself), because their distance value is more similar. Then their distance value and the similarity between them can also be obtain from Eq. (4) and Eq.(5):

$$d_* = |0.2 - 0|/1 = 0.2$$
$$s = 0.8/1.2 = 0.667$$

In respect with incompatible feature, for example, the case feature "device name" could take different values such as "current relay" or "voltage relay" etc, since all of its values have no relations with each other, the distance between them are the longest and its similarity has the following form:

$$d_* = 1 \quad \text{and} \quad s(p_i, p_{ij}) = 0 \quad \text{when} \quad p_i \neq p_{ij}$$

$$d_* = 0 \quad \text{and} \quad s(p_i, p_{ij}) = 1 \quad \text{when} \quad p_i = p_{ij}$$

Having calculated all similarity values $s(p_i, p_{ij})$ of the features between the current case and the retrieved case, and determined all weights in Eq.(2), we can obtain the similarity between two cases from Eq.(3). From Eq.(2), Eq.(4), Eq.(5) and Eq.(3), the result $0 \le S(C_0, C_j) \le 1$ is obvious. Then we arrange the cases in order of their similarity size, and eliminate those with small similarity($S<e$), forming the set of candidates Cs.

IV. CLASSIFICATION OF THE CASE BASE OF ELECTRIC ENGINEERING DESIGN

However, a case of electric engineering design is too complicated to be represented or retrieved. It's necessary to build case base's structure in three layers: global case base, local case base and case itself as shown in Fig.1.

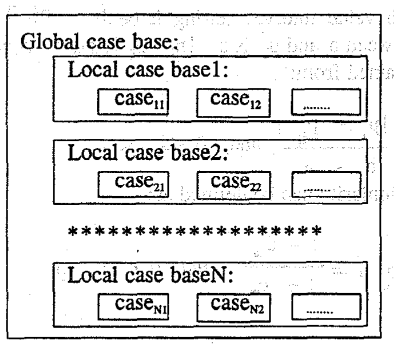

Fig.1 Structure of case base of electric engineering design

When the system is to retrieve a case in the global case base, the first place to find is the local case base where the case is. Then it's easy to determine the case itself.

Nevertheless, the implementation of the retrieving strategy needs some case features' leading. We have to classify the case features carefully for the work.

V. CLASSIFICATION OF THE CASE FEATURES OF ELECTRIC ENGINEERING DESIGN

Although there are numerous case features in electric engineering design, the authors classify them features as three groups: global features, local features, and micro-adapting features according to the size of their influence area on the case base.

A. Global features

Global features are those by which we can determine the local case base where a retrieved case is. Generally, they make a wide impact on the whole design scheme, change the entire structure of design volumes or books, and determine the existence of some subcases. The relationships between the global features and global case base are generally explicable, and can be represented in rule form. It is just the reason that expert system technology (i.e.rule-based reasoning) is widespread used in the scheme design. Although these global features are not enough for us to obtain the final solution: the retrieved case, they can lead the design procedure to find the local case base where the most similar case is, and extremely narrow the retrieval scope. The properties of global feature are concluded in Table 1.

TABLE 1
CLASSIFICATION AND PROPERTIES OF CASE FEATURES FOR ELECTRIC ENGINEERING DESIGN

Property	Global feature	Local feature	Adapting feature
Influence area	Whole design scheme volumes, and books	Structure of drawings	Graphic of drawings
Explicable	Yes	No	Yes for graphic No for case
Retrieving method	Knowledge-guided approach	Nearest neighbor approach	Nearest neighbor approach
Reasoning method	RBR	CBR	CBR for retrieving RBR for adapting
Function	Searching for local case base	Retrieving generalized case	Retrieving specified case Adapting generalized case

B. Local features

Local features are those by which we can determine the most suitable generalized case mentioned in Ref. [3]. They just make some impact on the partial structure of design scheme, for example, confirming the graphic layout and structure of design drawings. The knowledge generally is unexplainable, and difficult to be expressed in rule form. It is just the reason that current AI techniques hardly set foot in the field of graphic design. However with nearest-neighbor indexing strategy, the problem can be solved conveniently, that is to say, having established the local case-bases, we can obtain one or several similar cases by local features, and form the candidate case set. Obviously the cases are all generalized cases. Nevertheless, the design solution is the specified case[3] that still needs to use the adapting features.

C. Adapting features

Compared with global features and local features, the adapting features merely have an influence on the graphic variables inside design drawings. The relationships are easy to be defined with rules or procedures since those features act directly on every graphic object. For graphic primitives, the features are explicable. However, adapting features usually take various values, with which graphic primitives may change greatly, for example, some equipment specifications or settings in the equipment table. Furthermore, there are many adapting features and graphic primitives in a piece of drawing. So if every combination of graphic primitives has been registered as a specified case, the scale of the case-base would expand infinitely, and the system would lose the indexing ability for combinatorial explosion. This is just the disadvantage of current indexing method making use of database. Therefore, besides reserving some typical specified cases aptly, the case-base should mainly store the generalized cases with a wider adjusting range. What affects on such adjustments is the adapting features. By inspiring the operating knowledge inside each subcase, these features change the values of graphic variables, and convert the generalized cases into the specified cases. The specified would be stored into the specified case base if the case possesses the typical significance and may be applied with less adaptation for future projects.

Although relationships between adapting features and graphic primitives are explicable, those between adapting features and case or subcase are quite complex and difficult to explain. To retrieve the specified cases for design solution, we must use the local features and readjust features together in nearest-neighbor approaches. If failing, we retrieve generalized cases only with local features. The characteristics and functions of the three kinds of features in design cases are shown in Table 1.

VI. CONCLUSION

A CBR system derives its power from its ability to retrieve relevant cases quickly and accurately from its memory. Building a structure or process that will return the most appropriate case is the goal of the cases' organization and retrieval process. Generally, every case possesses its features, with which retrieval strategy could find relevant cases.

According to the relationship between a case and its features, the authors divide all the features into global, local and adapting features, and propose knowledge-guided approaches and nearest-neighbor approaches to retrieve relevant case and adapt it. Using this method, the author has successively built a CRBR system for electric engineering design.

VII. REFERENCES

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