Using Similarity Assessment in Case-Based Reasoning to Solve Power System Substation Problems

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Abstract

This paper presents the results from application back up of diagnostic decision supported by a Case Based Reasoning (CBR), with the presentation of a retriever prototype used for cases recovering from a specialist domain. Its aim is to recover, from a memory of cases, the most adequate case for a new situation and to suggest the solution for the new case.

Key-Words

Intelligent systems, case based reasoning, power system operation

Introduction

The paradigm Case Based Reasoning (CBR) presume the existence of a memory where the already solved cases are stored; uses these cases, through recovering, for helping in the resolution or interpretation of new problems; and promotes the learning, allowing that new cases (newly solved or newly spell-out) be added to the memiory [1].

One CBR uses previous cases as far for evaluation, justification or interpretation of proposed solutions (interpretative CBR), as for proposing solutions for new problems (problem solving CBR) [2].

CBR has been opening new fields on computer back up regarding decision problems of a bad structure. The CBR system purpose is to recover from its memory the most similar case regarding to the new, suggest the solution or one adaptation of this as a solution for the new situation. The usefulness of the old cases is made by the similarity access of a new case with the old one.

The central methodology of the retriever prototype is the similarity determination of a new case with all the previous cases. The similarities are set up through combination functions (matching) and through the characteristics of the new case with all the previous ones. In the next sections we will show how to handle with similarities and the matching function, so as the architecture of the retriever prototype.

Function Matching Modified Cosine

According [3] the function modified cosine is represented as follows:

$$Gcas = \frac{\sum_{i=1}^{m} \omega_i^n \omega_i^{p_k} \left(1 - \left(\frac{(x_i - y_i)}{R_i}\right)\right)}{\sqrt{\sum_{i=1}^{m} (\omega_i^n) \sum_{i=1}^{m} (\omega_i^{p_k})}}$$

for: i = 1,...m (descriptions) and
for: k = 1,...r (previous cases)

With:

$1 - \left(\frac{(x_i - y_i)}{R_i}\right)$ denotes the similarity in the i- th description of the new case and a previous case;

w_i^n º weight of i- th description on weight vector from new case;

$w_{i\,k}^p$ º weight of i- th description on weight vector from previous case.

The combination modified cosine determine the global similarity, named "*Matching degree*", **Gcas**, between two cases by comparison of terms frequency, that is to say, the description weight from the new case and the terms weight from previous case.

The function measures the cosine of the angle between the vectors weight of the new and previous cases, which cosine is weighed by the similarity degree along the space m-dimensions of descriptions. The denominator terms of equation above normalize the vectors weight by the determinations of its Euclidian lengths.

The similarity function is based in the pertinence (weight) of description values for the diagnostic. The similarity between the value of the present description from the new case and the value of same present description in the previous case of memory is taken as being the difference between the unit and a rate between the weights that each one of these values have for the diagnostic of the case in memory, with the extension value of the description scale.

The importance determination of one description is set up in one scale as per Figure 1. For example, presuming that the description of one specific system be the temperature and the determination of its importance pass through one scale which extension is defined as follow in Figure 2.

Figure 1 –Determination of Description Importance.

Figure 2 –Temperature Quality Values.

The similarity along the description may be computed, for example, for one value of *Very High Temperature* (2) in combination with a value of *Medium Temperature* (1,25) like:

Similarity along description = 1 - (2,0 - 1,25) / 2,0

Similarity = 0,625

Retrieve Process

The recovery process in Case Based Reasoning – CBR, comprises experience of past solutions stored into a memory known as *cases*. This technique aims to recover the most useful previous cases toward the solution of the new decision take problem and to ignore the irrelevant previous cases.

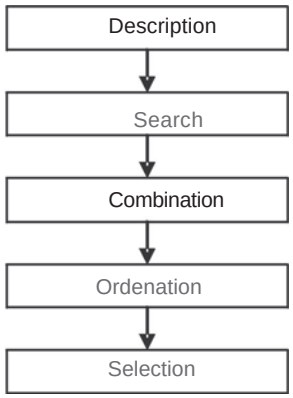

Figure 3 – Recover Components of one CBR

The cases recovery works in the following way, as set up in Figure 3: based upon the *description* of the new decision take problem (new case) the basic case is searched by the previous cases starting from a decision back up. The *search* is made based upon similarities [4].

The previous cases get through the combination function (matching degree) and are ordered in decreasing way regarding the matching degree. The combination function determines the similarity degree of the useful potential from previous cases with one new case.

The retriever prototype requires the whole evidence body supplied by memory, that is to say, it requires that the entry case matching degree be computed against all the memory cases.

In Figure 4 we see the Retriever Prototype architecture. For each memory case a matching function is defined between the new case and the same. This function computes the *Belief Function* in favor of the diagnostic of this case for the case of entry

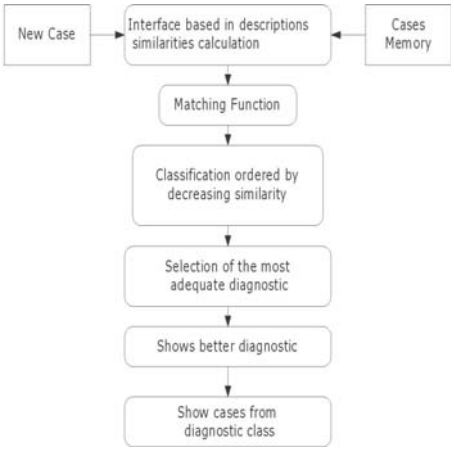

Figure 4 –Retriever Prototype Architecture.

The previous cases determined by search may be combined by **Gcas** and arranged in global similarity decreasing order.

In the diagnostic domain, it is usual that the cases in which the same diagnostic happens by symptoms groups or different characteristics.

"The most adequate diagnostic" supposed for the entry situation, is the one that presents the major evidence to its favor, in other words, the one that has a bigger Belief Degree, computed by the Matching Degree, **Gcas**.

"The most adequate case" suggested is the one among all the cases from the class of selected diagnostic, that have the bigger Matching degree **Gcas**. The cases that belong to that diagnostic class may be of help for the new problem solution.

The advantage in recovering the case is that it possible to find in it information that were useful the solution of previous problems which may help solving the new case.

Reasoning Based in Cases for Diagnosti

Decision Domain

The operator target is the value control of two kiln parameters, named *auxiliary circuit-breaker* and *voltage in bus 3*. These parameters values are set up by the operator considering four other parameters that are: *circuit-breaker 2, voltage in bus 2, current in transformer 2,* and *load level*. The condition attribute values when combined correspond to cement specific quality produced in the kiln, and for each one of these attributes adequate actions are expected to provide high quality. All attributes and its values are listed according Table 1.

In Table 2 are shown the possible diagnostics and its identification according to the descriptions *auxiliary circuit-breaker* and *voltage in bus 3*.

Knowledge Base

The knowledge base for CBR evaluation comprises 13 cases and is related to descriptions and with their diagnostics, as shown in Table 3.

Program Results for Retriever Prototype

The Retriever Prototype was tested for several New Cases, the results of the first New Case- [2 2 2 1] will be presented, that is to say, being the more simple Knowledge Base. For the New Case - [2 1 0 2], the used Knowledge Base already has a bigger Previous Cases memory, once its knowledge is more comprising.

Table 1 – Specification of Descriptions and its Extensions.

Attributes	Descriptions	Importance Scale
Condition	A circuit-breaker 2	0 - 3
Condition	B voltage in bus 2	0 - 3
Condition	C current in transformer 2	0 - 3
Condition	D - load level	0 - 3
Decision	E - auxiliary circuit-breaker	0 - 3
Decision	f voltage in bus 3	0 - 3

Table 2 - Diagnostics and its extensions

Diagnostic	e	f
D1	1	3
D2	0	3
D3	1	2
D4	1	1

Table 3 – Knowledge Base

Cases	a	b	c	d	Diagnostic
CASE 01	2	1	1	1	D1
CASE 02	2	1	1	0	D1
CASE 03	2	2	1	1	D1
CASE 04	1	1	1	0	D2
CASE 05	1	1	1	1	D2
CASE 06	2	1	1	2	D3
CASE 07	2	2	1	2	D3
CASE 08	3	2	1	2	D3
CASE 09	3	2	2	2	D4
CASE 10	3	3	2	2	D4
CASE 11	3	3	2	1	D4
CASE 12	3	2	2	1	D4
CASE 13	3	0	2	1	D4

a) New Case - [2 2 2 1]

Cases recovering analysys

Case found in Knowledge Base: 0

No Case Found

Calculation Process Begining

ORDER	Gcas	CASE	DIAGNOSTIC
1	0.9063	3	D1
2	0.8498	12	D4
3	0.8205	7	D3
4	0.8070	9	D4
5	0.8037	1	D1
6	0.7549	2	D1
7	0.7518	11	D4
8	0.7252	10	D4
9	0.7016	6	D3
10	0.6973	8	D3
11	0.6934	5	D2
12	0.6671	13	D4
13	0.6405	4	D2
14	0.6138	14	D4

New Knowledge Base:
Columns 1 through 15

C1	C2	C3	C4	C5	C6	C7
2	2	2	1	1	2	2
	1	2	1	1	1	2
1	1	1	1	1	1	1
1	0	1	0	1	2	2

C8	C9	C10	C11	C12	C13	C14	C15
3	3	3	3	3	3	3	2
2	2	3	3	2	0	1	2
1	2	2	2	2	2	1	2
2	2	2	1	1	1	1	1

Diagnpstics Belief Degree:

Cr(D1)= 8.216099e-001
Cr(D2)= 6.669439e-001
Cr(D3)= 7.398203e-001
Cr(D4)= 7.358005e-001

More Adequate diagnostic for new case

Bigger Belief Degree: 8.216099e-001
Bigger Belief Degree Diagnostic: D 1
Cases from More Adequate Diagnostic: C1, C2, C3

Previous case more adequate to the new case

Bigger Matching Degree: 9.062933e-001
Case with bigger Matching Degree: C3
b) –New Case - [2 1 0 2]
CASE RECOVERY ANALYSYS
Case found in Knowledge Base: 0
No Case Found

Calculation Process Begining

ORDER	Gcas	CASE	DIAGNOSTIC
1	0.9487	6	D3
2	0.8629	7	D3
3	0.7979	1	D1
4	0.7333	8	D3
5	0.7276	18	D3
6	0.7027	3	D1
7	0.6804	2	D1
8	0.6789	9	D4
9	0.6163	15	D1
10	0.6111	5	D2
11	0.6094	14	D4
12	0.5883	10	D4
13	0.5451	19	D2
14	0.5238	12	D4
15	0.4751	13	D4
16	0.4491	4	D2
17	0.4402	11	D4
18	0.2733	16	D4
19	0.1784	17	D4

Diagnostics Belief Degree

Cr(D1)= 6.993502e-001
Cr(D2)= 5.350826e-001
Cr(D3)= 8.181133e-001
Cr(D4)= 4.709396e-001

More adequate diagnostic for new case

Bigger Belief Degree: 8.181133e-001
Diagnostic of Bigger Belief Degree: D 3
Cases of more adequate Diagnostic: C6, C7, C8, C18

Previous case more adequate for new case

Bigger Matching Degree: 9.486833e-001
Case with bigger Matching Degree: C6

Conclusions

The basic idea in this work it is the knowledge retrieve process, in such a way that this knowledge be stored so as to allow us to simulate future actions in the diagnostics determination. We have presented architecture for a Retriever Prototype of cases from one CBR.

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