MODEL P : AN APPROACH OF THE ADAPTABILITY OF CASE-BASED REASONING SYSTEMS

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Abstract: This paper summarizes a new approach of the Cased-based Reasoning. The cases are not stored. The problem case solution is built as a puzzle. The puzzle obtained corresponds to the required solution. Each part is carrying information and has an associative behaviour. A piece seeks the piece which can be associated in width and in depth method. This associative behaviour is determined by several mechanisms: engine of expert system to binary rules, model of multicriterion choice of ordinal outclassing, search for close indices. A puzzle can thus have a complex mode of reasoning; each piece has a specific behaviour. The tool was tested on two applications of decision-making aid: identification of malaria facies and assistance to the specification of habitats. These applications made it possible to check the interest of this original framework. In particular it brings an elegant solution to the phase of adaptation in CBR technique.

1 INTRODUCTION

Research in the field of the C.B.R. (Case-Based Reasoning) is developed by Kolodner (Kolodner, 1988) then by Richter (Richter et al., 1993) and Veloso (Veloso et al., 1995). Paradigm C.B.R. is based on the model of Aamodt (Aamodt et al., 1994) represented by figure 1. The best of the knowledge is given by Watson (Watson, 1997). The C.B.R. is characterized by a adaptation step of an existing solution. It is allowed that the intervention of the user is necessary. The authors come up against a difficulty of formalizing this step in a generic way. Many authors resume works of Carbonell (Carbonell, 1986) on the analogy. The process of adaptation were exposed by Voss (Voss, 1997) and (Wilke et al., 1998). But the organization of knowledge in hierarchy (Kayser, 1997) opened new ways (Lieber, 2002). Let us examine the best of the knowledge of the re-use and the adaptation in the case-based reasoning systems.

2 ADAPTATION AND RE-USE THE BEST OF THE KNOWLEDGE

From the first research work on the CBR, a lot of proposals were about the problem of adaptability [Hinrichs 89][Turner 89]. Kolodner has proposed a classification of the types of adaptation [Kolodner 93]. He distinguishes the differences of methods and the differences of search for adaptation rules.
In 1996, Voss [Voss 96] adds to the cases identification criterion, the characteristics of the case type, with an estimation of the adaptation. [Purvis and al] suggest to exploit the constraints to guide the adaptation. This approach wants to assure the obtaining of consistent solutions. This implies that whole of constraints is complete and correct.
The Trinety College’s team of Dublin has studied the adaptation for the complexes systems [Smyth and al 93]. They are proposing in particular to learn rules of adaptation from a base of cases [Hanney and al 97].[Veloso 97] describes a mechanism which adapts the parts of case with a part of other cases. An interesting contribution has been brought by [Hanks and al 95] with an algorithm of plan based on cases and independent of the field.
[Leake and al 97 b] have imagined a process of adaptation with three types of learning: case learning by creation of responses plans, learning by indexation of case according to their use, case learning by search for similarity about the adaptation cost. But we notice that the improvement of abilities of adaptation and re-use go through new organizations of case-based reasoning systems [Kayer 97] [Lieber 2002].
For this reason the model P is proposed, with a new organization of knowledge.

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In many applications, the base of knowledge can be divided into several subsets, which are common with several cases. It is interesting to store these fragments not in several distinct cases, but in the form of pieces being able to be assembled. As for a puzzle, a case is reconstituted starting from pieces. The idea is not any more to store cases but pieces, which will be assembled and will form a new case : a puzzle.

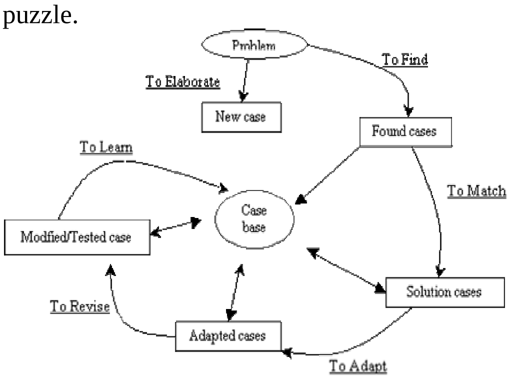

Figure 1: Principle of CRB Technique

3 THE CONCEPT OF PUZZLE

A puzzle is a progressive assemblage of pieces. For each problem, the user provides information to reconstitute a case (puzzle) which will bring a solution to the problem. Pieces, and their possibility of bringing together, will have been defined beforehand by an expert. The process, which leads to the formation of the puzzle-solution, is therefore directed by the choices of this expert. Its work establishes implicit bonds between the pieces, which guarantee to the user not to omit anything in its search for solution.

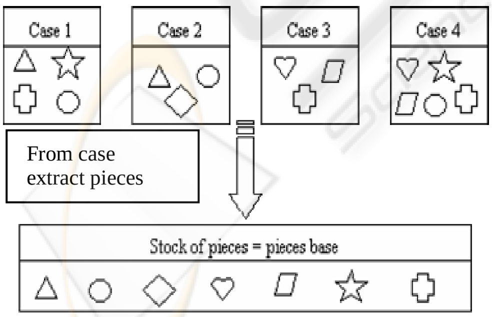

Figure 2: Principle of Modèle P

4 THE BASIC ENTITY: THE PIECE

A piece is a cellular object, composed of two information types:
- A descriptive information, more or less complex, on a precise subject, which can for example be materialized, in the simplest cases, by an image or a page HTML. That corresponds to a piece of puzzle.
- Information of pairing, guiding the choice of the pieces which will be connected to it. This information allows an automatic aggregation of the pieces, to form the puzzle. That corresponds to contours of a piece of puzzle. The pieces do not behave like passive objects. They have their own technique of selection of the successors and, as we will see it later, are able to adapt their search according to already selected pieces. The pieces can thus be compared with intelligent agents, holding account of their environment and semi-autonomous (because to user is sometimes solicited).
Here are two examples, on the topic of malaria.

4.1 Example 1: the piece "Facies river"

4.1.1 Descriptive information, in the shape of a html page

The facies River
The bank of the rivers are very touched zones. Indeed, many water holes are formed along the rivers: if these rivers are in withdrawal (like most of the time), the conditions are ideal for the development of the anopheles.
Here are some photos:

River in pre-forest zone (Cameroon)

Savane river

The zones at the banks of the rivers are high-risk zones of transmission of malaria in any season.

4.1.2 Pairing of the pieces

The pieces "Facies river" uses the method of *indexation*. This method, which uses the *key words* "river" and "malaria with permanent transmission", will be presented in the section “Techniques of pairing of the successors”, as for all the terms in italic. This piece belongs to the *field* "geo-climatic zone".

5 CONSTITUTION OF A PUZZLE

The aim is to bring, starting from the pieces of the base, a solution to the problem of the user. The used algorithm is recursive and built a puzzle: starting from the choice of the first piece, the relations with the not yet visited pieces of each piece are explored. The mechanism builds a tree with an in-depth exploration initially. The target piece represents the set of information provided by the user to initialise the search. It does not have descriptive information, and thus did not appear in the final puzzle.

The initialisation of the search for the first piece returns to the user. He has the choice of the technique of pairing of the successors, as well as filtering. According to the technique chosen, he can be asked to give more precise criteria. He defines the first piece of the puzzle, called target piece.

The search is done in a logical order : either from most general to more detailed, or in an order imposed by the nature of the problem. The choice of the possible successors based on two processes:

- Filtering : the choice is reduced at pieces having a common criterion.
- Filtering by fields: The pieces belong to a field, represented by a name. They also have a field of call, in which the search for the possible successors is carried out.
- Filtering by dates: the base evolves with time and new information, therefore certain pieces can become null and void, or less adapted to the situation. Each piece having a creation date, the choice is restricted at pieces former/posterior on a selected date.
- Techniques of pairing : In a field, the piece-successors are chosen either by asking the user for the contest, or by seeking the closest piece, according to criteria defined by the expert:

- Techniques by interrogation: selection on photo/description/HTML page, expert system, etc...
- Techniques of the nearest neighbour : indexation, multicriterion distance from outclassing, etc ...

Each piece indicates, according to the technique of pairing associated, a set of successors, which will seek another set of successors. This tree structure establishes relations which bring closer the information. Let us notice that it is impossible to take again a piece already selected under penalty of creating a circuit.

The combination of these two techniques of pairing makes easier the work of the expert : he can divide the general problem and classify the pieces in field, according to the technique of search.

This mixed method has an interest: the user is guided, directed automatically to certain tracks by the expert, and can redirect his search, with his initiative, using the techniques by interrogation.

Termination of the algorithm: There are two possibilities:

- The stock of pieces is exhausted
- All the started branches are finished, ie for each branch a sheet has been reached. Indeed, certain pieces can be defined as sheets by the expert. The pieces-sheets are those which do not search for a successor.

Associative bonds of the pieces: It is interesting to bind pieces whose association is necessary to the good understanding of the problem. These bonds are not commutative. Two associated pieces will thus be called in different contexts, but the selection of a piece will automatically involve the selection of its bonded piece.

Example from the application to the facies of malaria : In the struggle against malaria, the countries are classified in 3 types, corresponding to the recommended treatment. Burkina Faso pertains to group 2.

The piece Burkina Faso is related to the piece "country of group 2" (the choice of the piece "Burkina Faso" involves the automatic selection of the piece "country of type 2" as a successor).

This method makes it possible to choose at each stage the most adapted information, and provides in the end an answer "made to measure" to the question. The adaptation to the problem was made in a generic way, progressively. This approach which builds a search for solution as a puzzle is a great improvement of the stage of adaptation.

6 THE TECHNIQUES OF PAIRING OF THE SUCCESSORS

This chapter is not the best of the knowledge of these techniques. It presents the mechanisms implemented and tested in two applications. Two robust and innovating techniques are proposed: a multicriterion search and a reasoning with rules of production.

	C1	C2	C3
B	6	3	1
D	2	7	4
F	6	4	1

6.1 The nearest neighbours techniques

6.1.1 Indexation

Key words can be associated with the pieces, such as descriptors of the situation represented by the piece or the topics in connection with his subject.
The very close piece will have common key words, and more numerous they will be, closer the pieces will be, in the semantic network formed by the key words.
Indexation consists in listing the key words of the target piece, then to search for the pieces comprising the most key words of this list. Let us examine the following example :

The piece C calls pieces of the D1 field. It has the key words "i1", "i3" and "i7". The pieces of the D1 field are the pieces A, B, C, D, E, F
The pieces whose key words belong to the preceding list are: A ("i1" and "i3"), B ("i1") and D ("i1"). If the piece A is not taken yet, it will be chosen as a successor of the piece C. If not, the pieces B and D are retained jointly, with an equal number of common key words. (If they are not available any more, the piece C does not have any successors).
When there is filtering by field, if no piece of the field have common key words with the piece considered, it is possible for the user to widen the search to all the pieces of the base. This possibility also exists for multicriterion search.

6.1.2 Multicriterion search

This technique of pairing corresponds to certain problems. The idea is as follows: Several combinations of criteria can lead to the same choice, with the same solution. Several criteria can be associated to the pieces, which allow to make a multicriterion calculation of distance with ordinal outclassing. This outclassing avoids the circuits. Therefore the mechanism is robust. Two pieces will be close if they obtain a nearby total score.
Let us explain on an example: The piece B calls pieces of the D1 field, i.e. A, B, C, D, E, F. The criteria of the piece B are c1 (value=6), c2 (value=3)et c3 (value=1). The pieces having these same criteria are D (c1=2, c2=7, c3=4) and F (c1=6, c2=4, c3=1).
The following table is drawn up:

The outclassing number for B is : **1** on c1 **+ 0** on c2 **+ 0** on c3 =**1**
Score of outclassing of each piece :
B : 1
D : 4
F : 2
F is the piece to which the score is closest to B. Therefore F is B's successor. The tool also proposes to the user to spread the selection to the 2 or the 3 closest pieces.
That obviously requires to compare pieces having exactly the same criteria. As in the case of indexation, the first stage consist in finding the pieces having all the criteria of the target piece, then calculation is carried out.
This method can be applied to non-numerical criteria, but with an order. Example : code for colours.
Dark blue=1, light blue=2, green=3, yellow=4, orange=5, red=6, …

6.2 Techniques by interrogation

6.2.1 Expert system with rules of production

The engine of the expert system exploits a base of binary rules, with a no monotonous reasoning. It can use traditional rules of production which are translated into binary rules or directly binary rules. The absence of combinatory explosion in the engine allows a great robustness of operation. It always obtains a result and in a very fast time. The expert provides the rules and can associate piece-successors to the conclusions.

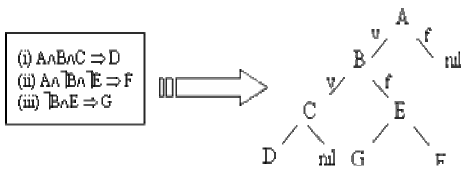

Figure 3: Transaction of the production rules into decision tree

The user thus will traverse the decision tree, while answering the questions until he reaches a sheet, itself connected at a piece-successor. The presence of isolated rules (under trees) can involve the selection of several pieces-successors.

6.2.2 Manual selection

This mode of selection consists in choosing among specifications the successors of the target part. The choice of the user is guided by descriptive information of the pieces: photographs and/or HTML page.
The expert can decide to declare a piece without successor. It can represent independent information, without possible continuation.

7 THE MODEL P IN ACTION

The application starts with a manual selection on the D1 field. The pieces proposed are A, B, C, D, E, F. A and E are chosen.
Study of the part E: The piece E is a sheet. However, this piece being associated at piece P, this one is automatically added in the solution tree. The piece P is a sheet.
Study of piece a: The technique of piece A is indexation, on the D1 field, with the key words "i1", "i2" and "13". The pieces successor are B and C, with two common key words ("i1 "and" i2 "for B," i1 "and" i3 "for C).
Study of piece b: This piece calls the pieces of the D1 field with the multicriterion technique. Calculation is carried out on the criteria c1, c2, c3, and the closest pieces are D and F (scores: score(B)=2, score(D)=1, score(F)=1).
Study of the piece D: This piece requires a manual selection on the D2 field, whose only piece is G. G is selected. G is a sheet.
Study of the piece F: This piece is an example of expert system.
What is the value of fact 1? answer = yes (to fact 2)
What is the value of fact 2? answer = no (to fact 4)
What is the value of fact 4? answer = yes (conclusion 2)
conclusion 2 is connected at piece N, which is a sheet.
Study of the piece C: The piece C uses a indexation on the D1 field. All the pieces of this field have already been selected. The user is asked if the field of search to have to be widen. After confirmation, search fails, because no piece have a common key words with those of C. C becomes a sheet.
A response or a different choice for a piece which has a technique of questioning can make trees of rather distinct form and contents. This shows the many possibilities of construction of the model. But, an already selected part cannot be selected twice.

8 CONCLUSION

This paper presents a new approach of the architecture of CBR tools. It wants to contribute a share to the problem of adaptability in techniques CBR. The mechanism proposed is based on a postulate: the cases of a field are decomposable (entities, sub problems, processes, diagrams, ...) and a component can be divided into one or more other cases. Only the components of a field are preserved. The case solution is built automatically as for a puzzle. Each part of the puzzle brings an element of the solution and associates the part in width and in-depth. A part has an information part and an associative behaviour. The mechanism is recursive. The depth of the puzzle is not limited. Several models of reasoning were implemented: engine with binary rules of production, indexing, multicriterion search of a case. In the same puzzle, several types of reasoning can cohabit. On two applications (detection of facies of malaria and identification of habitat), it showed its great flexibility of adaptation with a context. A greater effectiveness is obtained.
The user does not seek a case among a multitude of case but reconstitutes the nearest case with several possible reasoning. The updates relates to the stored parts, subsets of the puzzle, and the parameter setting of the models of reasoning.
Two applications have been developed. They permit to build up the know-how and to exploit it. Once concern the admission of the facies of the malaria. The other touch on the architectural expert or buildings. They have permitted to confirm the new concepts suggested.

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Model P framework

<u>phase 1</u>: identification of the possible piece for a puzzle (experts : Delphi method...)

<u>phase 2</u>: Construction mechanism of the puzzle and resolution of the problem