Chapter 1

Innovations in Case-Based Reasoning Applications

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Abstract. In this book, we have colleted a selection of papers on very recent Case-based reasoning (CBR) applications. Most of these propose interesting and unique methodological choices. The heterogeneity of the involved application domains indicates the flexibility of CBR, and its applicability in all those fields where experiential knowledge is (readily) available. The present chapter provides a brief introduction to CBR, for readers unfamiliar with the topic. It then summarizes the main research hints that will be analyzed in depth in the following chapters of this book.

1 Introduction

Case-based reasoning (CBR) [Kolodner 1993, Aamodt 1994] is an Artificial Intelligence (AI) technique to support the capability of reasoning and learning in advanced decision support systems. Specifically it is a reasoning paradigm that exploits the specific knowledge collected on previously encountered and solved situations, which are known as *cases*.

The reasoning process can be summarized using the following four basic steps. These are known as the *CBR cycle* (figure 1), or as the four *"res"* [Aamodt 1994]. The procedure is to:

(1) *retrieve* the most similar case(s), with respect to the current input situation, contained in the case repository, which is known as the *case base*;
(2) *reuse* them, or more precisely their solutions, in order to solve the new problem;
(3) *revise* the proposed new solution (if it is considered necessary);
(4) *retain* the current case for possible future problem solving.

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In many application domains it is also common to find CBR tools which are able to extract relevant knowledge, but leave the user the responsibility of providing an interpretation and of producing the final decision: steps *Reuse* and *Revise* are not implemented. In fact even retrieval alone may be able to significantly support the human decision making process [Watson 1997].

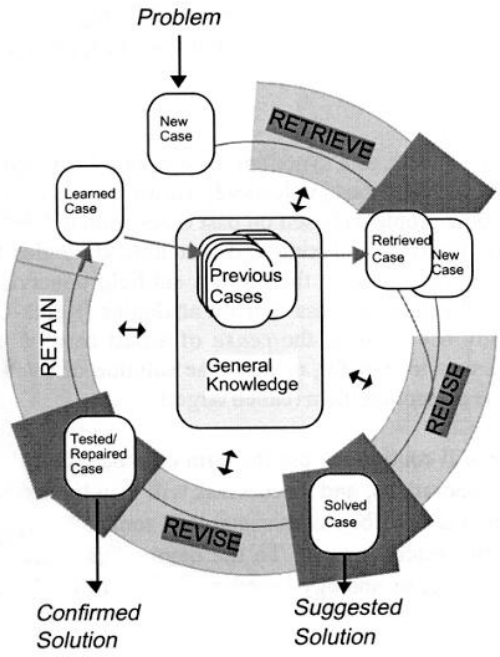

Fig. 1. The Case-based Reasoning Cycle (the picture is taken from [Aamodt 1994])

CBR is quite different from any other AI problem solving methodology - for example Bayesian Networks, Neural Networks, or Rule-Based Systems. That is because it does not aim to *generalize* from the examples. It keeps and exploits the specific instances of problems which have been collected in the past (almost) "as they are". Cases represent an implicit form of knowledge, i.e. an unstructured, operative knowledge type, which is intended to be a store of past problem/solution patterns. In classical CBR no effort is made to extract more abstract information, that is there is no attempt to elicit rules or models from cases.

By using CBR, the difficulties of knowledge acquisition and of knowledge representation are therefore often lessened. The new implicit knowledge generated by an organization/company can be automatically learnt, and stored in the case base by means of the *Retain* step, each day the organization operates. The case library then grows, and more and more representative examples can be retrieved. This makes it easier to find an appropriate solution to the present problem using this

paradigm. This however implies that proper case base maintenance policies have to be defined.

CBR basics are also considered in **Chapter 2**.

The first publications on CBR appeared in the 80s. It is therefore a relatively "young" methodology. Nevertheless, CBR research has soon become very active, as testified by the large number of theoretical and applicative works. Theoretical works have ranged from the design of a similarity measures and of fast retrieval strategies by the use of memory organization [Wilson 1997, Bichindaritz 2008], to adaptation and revision techniques [Patterson 2002], and to case base maintenance [Leake 2001]. Applications have been proposed for use in several domains. These include legal reasoning [Elhadi 2001], health sciences [Jurisica 2004, Montani 2008], web services [Lorenzi 2005] and Ambient Intelligence [Deutsch 2008], citing only a few examples.

We have selected 8 significant works on CBR applications, which testify to the flexibility and the practical advantages of this reasoning methodology. Details of the collected contributions are given in the next section.

2 Chapters Included in the Book

In the following chapters, we present a selection of some very interesting CBR approaches, which are applied to a variety of application domains.

In general, medical and industrial applications play a central role in the collected chapters. The rapidly growing amount of experience, and possible difficulties in generalizing of the available data in a strong domain theory, make CBR a very suitable methodology for aiding decision making in these areas. CBR resembles human reasoning, and allows to easily store experienced colleagues' "know-how", even in exceptional situations (e.g. [Surma 1995]). Moreover, proper methodological choices, such as the integration of CBR and other (AI) techniques, can enhance the performance of the resulting decision support system [Montani 2008].

These points are explored in **Chapter 2**, entitled "Case-Based Reasoning for Medical and Industrial Decision Support Systems" (Mobyen Uddin Ahmed, Shahina Begum, Erik Olsson, Ning Xiong and Peter Funk). In the chapter, the authors discuss the main features of ***medical and industrial CBR applications***. Some specific tools and their development in these domains are also presented.

The next three chapters broaden the issue of designing and implementing CBR systems in an ***industrial context***. **Chapter 3**, entitled "Development of Industrial Knowledge Management Applications with Case-Based Reasoning" (Mehmet H. Göker, Catherine Baudin and Michel Manago), illustrates the main software engineering steps necessary for designing a CBR-based knowledge management industrial tool. The main potential problems and peculiarities of this application field are highlighted. Suggestions for solutions based on the authors' own experience in business organizations are considered. **Chapter 4**, entitled "Case based Reasoning for Supporting Strategy Decision Making in Small and Medium Enterprises" (Jerzy Surma) deals with the definition of a CBR tool for use in an enterprise. In particular, it focuses on STRATEGOS, a tool which provides a CBR approach for supporting strategic management in areas of great decision complexity and uncertainty.

Chapter 5, entitled "Heterogeneity in Ontological CBR Systems" (Amjad Abou Assali, Dominique Lenne, and Bruno Debray) is more specifically related to a single industrial domain. It presents a knowledge-intensive CBR system used for diagnosing failures of gas sensors. From the methodological viewpoint, the system relies on ontological knowledge. This is also used for case retrieval, and takes into account the heterogeneity of case description.

The focus then returns to ***healthcare applications***, a domain in which CBR research is extremely active [Marling 2009]. In particular, **Chapter 6**, entitled "The Adaptation Problem in Medical Case-Based Reasoning Systems" (Rainer Schmidt and Olga Vorobieva) analyses different approaches of medical CBR systems to the adaptation and revision tasks. It exploits the great experience the authors have in the field to properly exemplify specific features and results. **Chapter 7**, entitled "A Prototype-Based Classification in Unbalanced Biomedical Problems (Sara Colantonio, Suzanne Little, Ovidio Salvetti and Petra Perner) presents the evaluation results of a case-based classifier used on three data sets – one of which is medical data - compared with other classical approaches. The case-based classifier exploits feature selection and feature weighting to improve its performance.

Finally, the last two chapters testify to the flexibility of CBR and to its suitability for use on a wide range of application domains. In particular **Chapter 8**, entitled "Case-Based Ranking for Environmental Risk Assessment" (Paolo Avesani and Angelo Susi), presents the use of a CBR approach to ***environmental surveillance***. It introduces a case-based ranking methodology, and provides very encouraging experimental results in two different environmental risk assessment evaluations. On the other hand **Chapter 9**, entitled "CookIIS - a successful Recipe Advisor and Menu Creator" (Alexandre Hanft, Regis Newo, Kerstin Bach, Norman Ihle and Klaus-Dieter Althoff), reports on very interesting research issues, mainly dealing with adaptation and revision, afforded in a tool for suggesting ***cooking recipes*** as well as complete menus.

3 Conclusion

This book collects a set of successful CBR approaches. These, after an in-depth analysis of their specific application domain needs, propose proper methodological solutions and give encouraging evaluation results, which have sometimes led to the commercialization step.

The collected chapters exemplify how to build industry-focused and healthcare tools, which testifies how the CBR technology is not solely confined to academic research.

They also demonstrate the capability of CBR to solve or handle issues which would be too difficult to manage with other classical AI methods and techniques, such as rules or models. This capability emerges very clearly in the health sciences.

In conclusion, the heterogeneity of the involved application domains demonstrates the flexibility of CBR, and demonstrates its applicability as a decision support methodology in those fields where experiential knowledge can be easily (and possibly automatically) collected and reused.

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