Case-Based Reasoning in Diagnostic Problem Solving: Alternative or complementary to MBR?

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Abstract. Case-based reasoning is a problem solving paradigm which emphasizes the reuse of stored cases to solve new similar problems [2]. The cases are composed by a problem description (in simple domains just a list at attribute, value pairs) and by the solution to the problem. CBR involves a number of techniques for indexing cases, retrieving them, possibly adapting the retrieved solution, and for managing the case base.
Since the competence of a CBR is strongly affected by the ability of retrieving cases, which fit well the description of the new problem, a critical aspect concerns the definition of the similarity measure to be adopted for retrieving cases.

Since the early days of CBR, diagnosis has been one of the relevant area of applications of CBR (see [2], [3]). In particular, CBR has been applied to domains where there is just a weak domain theory and /or the modeling effort is considered too big. It is worth noting that in most of such applications there is the implicit assumption that a diagnostic problem can be reduced to a classification problem. In other words, after the retrieval of the most similar cases and a decision process, the solution of the new problem (the diagnostic conclusion or the repair action) is the solution of one of the retrieved case.

In the CBR community several methods have been developed for performing adaptation, that is for modifying the solution of the retrieved case in order to making it a solution of the new problem. Adaptation is a difficult task and requires additional knowledge on the domain apart the one contained in the cases and in the retrieval mechanism. However, adaptation seems to be a relevant step in case-based diagnosis, in particular when diagnosis cannot be reduced to classification.

In recent years the development of Conversational CBR [1] has extended the applicability of CBR: in fact, Conversational CBR systems can be viewed as interactive systems which can guide the user trough a question answering sequence during the phase of case retrieval. This approach avoids the need of providing a complete description of the new problem to be solved before the activation of the reasoning mechanism. Conversational CBR has attracted a significant amount of attention because systems based on this approach seem to fit well the needs of customer support, interaction between customers and call center personnel. CCBR has been used in a number of diagnostic/troubleshooting applications: it is worth noting that these system usually do not have a " model" of the system to be diagnosed but are based on past experiences and/or best practices (see, for example, [5]).

One of the typical advantages associated to CBR is the reduced effort in acquiring the domain knowledge. While this is true in many cases, it is worth noting that the collection of a (large) number of solved cases is not a guarantee for a CBR system to exhibit a high competence. In particular, case memory management requires sophisticated techniques for taking care of the "swapping problem", similarity and diversity of the cases, coverage of the domain, strategies for adding and forgetting cases (see [12] for a general discussion).

While in the early days of CBR, this reasoning mechanism was often used stand alone, starting from beginning of nineties an increased amount of work has been devoted to case based integration. In this approach CBR is combined with other reasoning mechanisms usually Rule-based reasoning, CSP or Model based reasoning [12]. The role of CBR and of the other reasoning mechanisms may be very different in different domains.

However, an important contribution to the understating of the role of CBR has been done in the area of planning where the PRODIGY system [11] showed that relevant saving in computational cost can be achieved if the new problem is not solved by scratch (via classical generative planning mechanism) but the structure of the solution of a retrieved case is used for solving the new problem.

The reuse of past solution for solving new problems has been also formally investigated for planning and results for the computational complexity of such step exist [6].

Our research group has investigated the problem of a strict integration of CBR and MBR in the field of diagnosis. In this paradigm the two approaches share the characterization of diagnosis (they use the same definitions of the notion of diagnosis) and the qualitative (logical) model of the domain. The basic idea is to retrieve cases from the case memory that can be easily adapted to be a solution for the new diagnostic problem. Adaptation is performed by exploiting the domain theory and the reasoning mechanism also used for MBR. When the CBR fails to provide a solution to the new diagnostic problem, MBR is invoked to search for a solution. If MBR succeeds, the solution to this problem provided by the MBR module is added to the case memory; in this way, the CBR becomes more and more competent along time.

We have critically examined this paradigm [7]: the computational complexity of solving a new problem by adapting a solution of a past case is not guaranteed to be lower than solving a diagnostic problem from scratch. However in most cases there are significant saving from a computational point of view and suitable learning and forgetting strategies allow to build competent case bases even if we start from an empty case memory [8].

Instead of using a fixed strategy (CBR first and then MBR in case of failure of CBR) we have developed (and experimented) opportunistic strategies that combine CBR and MBR in

different ways according the estimated difficulty of the diagnostic problem [3].

The results [9] show the relevant benefits of such a strict integration between CBR and MBR, that is possible when a qualitative model of the domain is available.

REFERENCES

[1] D.Aha, L. Breslow, H. Munoz-Avila. 'Conversational Case-Based Reasoning'. *Applied Intelligence*, **14**, pp. 9-32, 2001.

[2] J. Kolodner, *Case based Reasoning,* Morgan Kaufmann, 1993.

[3] D. Magro, P. Torasso. Performance issues in unimodal and multimodal reasoning approaches to diagnosis, Proc. DX 2000, Morelia (Mexico) 2000.

[4] C. Marling, M. Sqalli, E. Rissland, H. Munoz-Avila, D. Aha, 'Case-based Reasoning Integrations', *AI magazine*, **23** (1), pp.69-86, 2002.

[5] McSherry. 'Interactive case-based reasoning in Sequential Diagnosis'. *Applied Intelligence*, **14**, pp. 65-76, 2001.

[6] B. Nebel, J.Koehler. 'Plan reuse versus plan generation: a theoretical and empirical analysis'. *Artificial Intelligence*, **76**, pp.427-454, 1995.

[7] L. Portinale, P. Torasso. On the Usefulness of re-using diagnostic solutions. Proc. ECAI 96, pp. 137-141, IOS Press, 1996.

[8] L. Portinale, P. Torasso. 'Case Base Maintenance' in a *Multimodal Reasoning System*, **17** (2), pp. 263-279, 2001.

[9] L. Portinale, P. Torasso, D. Magro. 'Multi-modal Diagnosis Combining Case-Based and Model-Based Reasoning: a Formal and Experimental Analysis'. *Artificial Intelligence* (to appear).

[10] I. Watson. *Applying Case-Based Reasoning: Techniques for Enterprise Systems*, Morgan Kaufmann Publishers Inc., 1997.

[11] M. Veloso. 'Planning and learning by analogical reasoning'. Lecture Notes in *Artificial Intelligence*, **886**, Springer Verlag, 1994.

[12] D. Wilson, D. Leake. 'Maintaining Case-Based Reasoners: Dimensions and Directions'. *Computational Intelligence*, **17** (2), pp. 196-213, 2001.