

# Case-Based Reasoning

## Introduction and Recent Developments

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**Case-based reasoning (CBR) is a sub-field of Artificial Intelligence that deals with experience-based problem solving. CBR has its roots in different disciplines such as cognitive science, machine learning, and knowledge-based systems. Today, it is a well established research field of its own, which produced a rich variety of specific methods, as well as applications implementing those methods for particular tasks and domains. This paper gives a compact overview of CBR in general and further discusses recent advancements in selected topics.**

## 1 Introduction

Case-based Reasoning (CBR) is a well established research field in Artificial Intelligence that involves the investigation of theoretical foundations [27], system development, and practical application building [10] of experience-based problem solving. The core of every case-based problem solver is the *case-base*, which is a collection of previously made and stored experience items, called *cases*. A case-based problem solver solves new problems primarily by reuse of solutions from the cases in the case base. For this purpose, one or several relevant cases are selected. This selection process is guided by one of the core assumptions behind CBR, namely that *similar problems have similar solutions*. Once similar cases are selected, the solution(s) from the case(s) are adapted to become a solution of the current problem. Finally, when a new (successful) solution to the new problem is found, a new experience is made, which can be stored in the case-base to increase its competence, thus implementing a learning behavior.

CBR has its roots in different disciplines, particularly cognitive science, machine learning, and knowledge based-systems, including knowledge representation and reasoning. CBR research is also related to various topics in information retrieval, data bases, semantic web, and knowledge management. CBR is to a large degree characterized by the fact that it combines methods from different areas in AI in a particular manner for the purpose of experience-based problem solving. Hence, there is a strong focus on developing frameworks for a broad spectrum of problems (e.g. diagnosis, planning, product recommendation, experience management) as well as on implementing case-based systems for certain application domains (e.g. for medicine). However, there are also several CBR-related tasks for which other AI disciplines do not already provide a solid methodological foundation. For example, CBR research made significant original contributions to the field of similarity modeling, similarity-based retrieval, and adaptation. As several reviews of CBR exist [28, 32, 1], this paper provides only a compact overview on CBR in general and focusses on recent advancements in selected topics.

## 2 Knowledge and Reasoning in CBR

We now briefly describe CBR from the perspective of knowledge representation and reasoning as this view shows the similarities and differences to traditional methods used in AI.

### 2.1 Types of CBR

There are three main types of CBR that differ significantly from each other concerning case representation and reasoning: *structural*, *textual*, and *conversational* CBR [10]. The idea underlying the *structural* CBR approach is to represent cases according to a common structured vocabulary, i.e. an ontology. Once this vocabulary is defined, all cases are restricted to represent experience that can be expressed with this vocabulary. In the various structural case representations, the describing features of a case may be organized as flat attribute-value tables, in an object-oriented manner, as graph structures, or by sets of atomic formulas of a predicate logic language. The structural CBR approach is most widely used and will therefore be the focus of the remainder of this survey.

In *textual CBR*, there is no common case structure, but cases are represented as free text, i.e. strings [31]. This is very useful in domains where large collections of know-how text documents already exist and the intended user is able to make use of the experience contained in the respective documents immediately.

In *conversational CBR* [5] cases aim at capturing the knowledge contained in customer/agent conversations. A case is represented through a list of questions that varies from one case to another. There is no ontology and no standardized structure for all the cases.

Today, structural CBR approaches make also use of features from textual and conversational CBR. For example, textual cases can be mapped to a structural representation by information extraction and by methods for automating ontological annotations. Also, dialog components are used as parts of CBR systems to implement specific strategies for user interaction.

### 2.2 CBR Cycle

Despite the many different appearances of CBR systems the essentials of CBR are captured in a surprisingly simple and uniform process model (see Fig. 1), the CBR cycle proposed