

A case base of Case-Based Design tools for architecture

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Abstract

In the 1990s, Case-Based Design (CBD) seemed an appealing approach to develop intelligent design support. Based on an alternative view of human cognition, CBD systems find new design solutions by adapting similar experiences from the past. Although several CBD applications have been built, a convincing breakthrough by these systems has yet to come. In search of reasons for this limited success, this article embarks on a critical review of the CBD approach. Its underlying cognitive model serves as a framework to analyse six CBD systems and to identify gaps in CBD research. The article focuses primarily on CBD applications for architecture, yet the findings may be relevant for other design domains as well. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

Computer-Aided Architectural Design (CAAD) has gone through many generations and philosophical perspectives. In the early and mid-1990s, a rather popular one was CBD—the application of case-based reasoning (CBR) to the task of designing [1]. In recent years, however, it has become rather quiet at the CBD front. Although the cognitive model underlying the CBD approach seems to provide a plausible explanation of how architects/designers acquire and use (design) knowledge, systems that flow from CBD research have rarely become widely used tools in offices and schools of architecture. Was CBD the umpteenth flash in the CAAD pan, or is it still a valuable path to follow?

Whereas previously we have tried to answer this question on a more theoretical level [2], this article puts some specific CBD projects under the microscope. It is so to speak a case base of CBD systems for architecture and contains six quite different cases of CBD research: Archie-II, CADRE, FABEL, IDIOM, PRECEDENTS and SEED. The six were selected because of their special concern with the domain of architectural design and because, taken together, they give a fairly good overview of the various directions in CBD research. Each case study starts with a brief introduction into the main objectives and focus of the CBD system and subsequently describes how (and whether) the different

ingredients of the CBD recipe—case base (content, representation and memory organisation), retrieval and manipulation—are implemented.¹ A great deal of work in this area has been published in various journals, conference proceedings and books. To our knowledge, however, this work has hardly been subject to any critique or discussion. For instance, Mary Lou Maher, Andrés Gomez de Silva Garza and Pearl Pu [5,6] give an overview of major contributions to the field of CBD, including several systems addressed in this article, but hardly go beyond a neutral description of their features. Nevertheless, a discussion on these systems is certainly worth developing and is therefore initiated at the end of each case study. The article ends by continuing this discussion in more general terms.

Before embarking on the first case study, one may ask why we want to review CBD research in the first place. The answer is that, although a convincing breakthrough by CBD tools has yet to come, there are strong indications that encourage us not to brush the entire CBD enterprise aside. One indication is a recent experiment on the effects of using cases in architectural design, which shows that student architects effectively benefit from exposure to cases during the design process [7].

¹ There is neither space nor need to describe all details of the CBD recipe in depth in this article. A concise description of its promises and underlying cognitive model can be found in [2] and [3] respectively, a more detailed one in chapter 2 of [4].

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2. Case 1: Archie-II

Archie-II is a CBD aid for architects developed at the AI lab of Georgia Tech's College of Computing in collaboration with members of Tech's College of Architecture [8–10]. It descends from an earlier system called Archie, which was one of the earliest CBR applications in the domain of architectural design. Archie-II supports architects during the early conceptual stage of public building design, by providing them with interesting design cases from the past. The system focuses on case representation and retrieval, leaving manipulation completely to the user.

2.1. Description

Archie-II contains the records of several courthouses and libraries. Existing descriptions of these buildings—blueprints and specifications—are augmented with evaluations of how the designs turned out, which were collected by spreading surveys across several stakeholders.

Design descriptions including the details of something as large as a courthouse or library are too extensive to assist architects' design decisions directly. Adding evaluations swells cases even further, yet, at the same time, provides a key to break cases into more manageable chunks. Useful evaluations focus on those features that are exceptionally good or particularly bad, and thus worth storing for the future. Describing these interesting parts by short pieces of text, Archie-II ends up in slicing its cases into stories. Three types of stories can be distinguished: *point stories* describe how certain features of a design (e.g. separated entrances) contribute towards or undermine some particular goal (e.g. privacy); *interaction stories* discuss how features of a design case can be interpreted with respect to several design goals (e.g. privacy, security, circulation), perhaps advancing some while frustrating others; whereas *cluster stories* summarise several point stories that are located close to one another (e.g. all stories about a particular room).

Apart from stories, Archie-II contains a second type of knowledge chunks, called *guidelines*. By generalising groups of particular experiences, these guidelines propose ways of thinking about a design, rather than providing absolute answers to design problems.

As to the representation of these knowledge chunks, users can choose between five possible modes: library, description, plan, notebook and history. In the plan mode, for example, the system displays the floor plan of a particular building with some annotated cluster stories, including the complete story text, source and links to related knowledge chunks. In addition to floor plans, stories and guidelines may be illustrated by abstract schemes that highlight the building zones or parts at issue.

A useful scale version of Archie-II will contain a huge number of stories and guidelines, in which users should find their way easily and quickly. Hence the need for an indexing system that allows retrieving the right case at the right time,

or rather the right chunk of the right case at the right time. Archie-II distinguishes between two kinds of indices. *Descriptive indices* identify design stories by means of a design issue plus at least one of the following features: building space, functional component, stakeholder perspective and phase in the building's life cycle.² *Relationship indices*, on the other hand, are bi-directional hard links between two presentations that direct users' attention to related material—for instance from an interaction story to its underlying point stories, from a guideline to point or interaction stories that illustrate its application or failure, or from a cluster story to the point or interaction stories it summarises.

Archie-II offers two possibilities for retrieving relevant cases. Descriptive indices support directed search, while relationship indices allow the user to browse through related stories and guidelines. Once a case is retrieved, the task of Archie-II is finished. The user bears the complete responsibility for understanding and applying (or ignoring) the information presented.

2.2. Discussion

An interesting aspect of Archie-II, in our opinion, is to use evaluations of existing designs as source of design knowledge. Making evaluative material available to architects early in the design process can make them more aware of the downstream implications of their decisions. Design decisions have consequences for people who will carry out, use and maintain the building. By storing stories from all these people, Archie-II draws architects' attention to all life-cycle implications of their design early in the design process. Collecting such stories seems less intrusive than demanding architects to record the justifications of their decisions during design. When building users are proud of the way something works, they are happy to talk about it, and when something bothers them, they are quick to complain.

A second asset of the system is its attempt to fit architects' designerly way of thinking. Architects do not consider the different aspects of a design separately, but always in relation to other issues [11]. When designing holding cells, for instance, they will not dwell on the problem of safety first and reflect on privacy afterwards. All these considerations are running through their head simultaneously. Archie-II's descriptive indices attempt to support this kind of thinking, by allowing users to search information on several aspects of a design at the same time. Furthermore, the sophisticated indexing system enables Archie-II to follow architects' 'juggling' from one design aspect to another [11]. For example, they may start to investigate acoustic issues in the courtroom, subsequently move to another type of room, then

² Since interaction stories discuss how several design issues are differently affected by some feature of the design, their index should contain more than one design issue. Archie-II solves this problem by descriptive indices with two parts, each mentioning a different issue and outcome.

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