

What a Shame — Why Good Ideas Can't Make It in Architecture

A Contemporary Approach towards the Case-Based Reasoning Paradigm in Architecture

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Abstract

The paper deals with the application of the Case-Based Reasoning Paradigm (CBR) in Design Support Systems in Architecture. Based on the finding that promising concepts and systems do exist in architecture the question as to why they do not gain the anticipated success is explored. In search for reasons a comprehensive comparison between the cognitive model and the derived conceptual method, theoretical contemplations of architectural design as well as the actual application of the method in CBR systems in Architecture, manifests the core of the work presented.

Introduction

The problem solving theory CBR is based on the assumption that humans understand situations and solve problems based on their own experiences. The heart of the Paradigm manifests experience-based learning and creation. One of the fundamental arguments for applying CBR in computer systems in general is to prevent the repetition of mistakes from the past but to build on past success.

It is said that architectural design constitutes an experience-based process (see e.g. (Boerner 1997; Heylighen 2000), that design problems underlie specific principles (Kolodner 1993) and that architects, in solving new design tasks, regularly and extensively make use of past solutions in the form of exemplary architectural objects (Domeshek and Kolodner 1992; Oxman and Oxman 1994; Boerner 1997; Achten 2000; Heylighen 2000; Taha 2006; a. a.). Since the beginning of the 1990's numerous systems which support this approach came into existence.

Problem Statement

Taking stock one has to acknowledge that after 20 years of CBR research in Architecture numerous comprehensible and seemingly promising applications in the form of academic concepts and prototypes have been developed. One also has to realize that these concepts and system do not meet the high expectations: They did not show the impact on architectural education nor architectural practice that was hoped for.

The situation depicts itself as following: No commercially available CBR system exists which supports design in architecture in the professional practice.

Academic activities around CBD in architecture, Case Based Design as the generic term for CBR-based systems which support design in the widest sense, took place notably in the initial phase. However the developed systems never left their academic home.

Highly acknowledged in the scientific world were systems such as FABEL (1992-1996), a research project at the GMD (Gesellschaft für Mathematik und Datenverarbeitung mbH – Society for Mathematics and DP, today's Fraunhofer Society), and SEED (1992-2001), a modular computer system for the support of the early design phases, developed at Carnegie Mellon University, Pittsburgh (PA).

The Design Support System DYNAMO is perhaps the most significant existing CBD System in architectural education as well as in research.

It has to be noticed that comprehensive scientific studies, which (based on the pros and cons of CBD) come to a final decision regarding the application of CBR to architecture do not exist.

It can be said that it is difficult to elude from the plausibility of the model and its underlying ideas. Similarly, arguments which support the application of CBR in architecture are not easy to dismiss: Architects learn from experiences and make use of exemplary architectural objects during design. The question arose why systems, which are based on these observations, do not win broader recognition.

The early attempt to find answers to this question already showed that the understanding of CBR in Architecture, chosen premises as well as the interpretation of the underlying model and derived method underlie enormous variations. From this the following hypothesis was derived:

A consistent comprehension of the subject matter of CBR in Architecture does not exist.

Two extremes of CBR systems in architecture can be determined: There are systems, which solve (sub-) tasks of architectural design totally independently. One might recognize them as CBR based Design Automation Systems (Maher et al. 1995) or Autonomous Case based Design Systems (Goel and Craw 2005). On the other end systems exist which simply support the designing architect with information about architectural artifacts. These systems are called Case-based Design Assistants (Maher et al. 1995), Case-based Design Support Systems or Case based Design Aids. Although the focus in discussing CBR in Architecture is on Design Support Systems both extremes were closely investigated.

Research objectives

Aim of the research presented was to explore discrepancies in the CBR theory and its interpretation, which might give indications for reasons behind the limited success of CBR in architecture.

Therefore a comparison between the cognitive model and the derived method, theoretical observations of the architectural design process as well as the application of the method in CBR-based Design Support Systems in Architecture has been conducted. The Hypothesis which manifests the basis for this approach was: Reasons for the limited success can be found in the mistakable interpretation of the model and a limited consideration of the architectural practice.

Findings

Theoretical observations in four different directions have been conducted:

- The cognitive model and its underlying theory have been reviewed.

- Work on the conceptual method which derived from the model was reviewed and structured.
- Theoretical reflections of the special characteristics of architectural design and practice have been put into context.
- Based on the analysis of 21 systems and concepts the application of CBR in architecture has been investigated. 6 of these systems could be classified as CBR based Design Automation Systems, 7 as Case-based Design Support Systems, 2 as hybrids between Design Support Systems and Case-based Learning Systems (CBL-Systems), another identified form of applied CBR in architecture, and 6 as pure CBL Systems.

Through these investigations three problem areas have been identified:

- Problem area 1: Architectural design and the application of the method in computer systems in architecture
- Problem area 2: The method and architectural design
- Problem area 3: The method and its application to computer systems in architecture

The most important findings are as follows:

General findings and explanatory notes

Special characteristics of architects and the architectural practice indicate problems for a successful application of the method in architecture:

General observations showed that the predominant fear of design fixation and the overestimation of originality, the latent reservation towards learning from mistakes (of others) as well as the lack of integration of CBD tools in the digital work environment of architects form the breeding ground for these problems. Not to underestimate are additional unforeseeable market regulation mechanisms as well as the completely unaddressed questions of copyrights. The solution of only a very small number of these problems falls into the area of influence of CBD developers.

Problem area 1: Architectural design and the application of the method in architecture

The majority of systems and concepts reviewed follows a very limited interpretation of the model and method of CBR. This limitation stems from prioritizing the meaning of solutions of past problem solving episodes in solving current design problems. This is based on the simplified assumption that similar problems have similar solutions (see also (Richter 2003)).

The core of the majority of systems reviewed comprises the solution of a design problem: the designed and built architectural object. Experiential knowledge is not represented. The main reason for this fact is an oversimplified definition of the term 'case': To provide experiential knowledge for interpretational and problem

solving tasks in Case-based Computer Systems the theory suggests a tripartite structure for the case representation consisting of problem, solution and outcome (Kolodner1993). In discussed systems crucial case components are not provided. The outcome of this is in fact that Learning and Creating based on the experiences of others is not supported by these systems.

There is no common understanding of CBR in architecture. This fact implicates that the inconsiderate use of the term 'CBR in architecture' is actually to be judged critical since it preassigns misunderstandings. Differing opinions of model and method lead to differing characteristics of individual applications.

Three views on CBR in architecture

Based on the different roles which developers ascribe architectural solutions in their systems three clearly definable views could be identified, after which these systems allow for:

- Access to solutions in the sense of repositories for referential object or architectural precedents;
- Reuse of solutions based on a simplified interpretation of model and method;
- Reuse of experiential knowledge, obeying model and method compellingly.

Investigations showed that depending on the individual view and according to the intentions in developing CBD systems aspects like the time of use in the design process, accordingly query strategies, as well as the answering questions related to knowledge acquisition need to be addressed differently.

Problem area 2: Method and architectural design

The comparison between premises underlying the method on the one hand and theories on the special nature of design process and design problems on the other revealed reasons for the fact that:

- The implementation of search and retrieval mechanisms in CBD systems proves crucial.

If one follows the assumption that design is a solution focused process and acknowledges concepts like Situatedness and under determination in theory a discrepancy becomes evident with the concept of a conscious problem oriented search underlying the CBR paradigm. The consideration of this finding must lead towards a more explicit positioning when it comes to addressing and developing suitable query strategies in function of intention and intended time of use in the design process of the CBD system to be developed.

For the application of the CBR paradigm in computer systems in architecture applies:

- Problems exist which are similar to knowledge acquisition problems in traditional expert systems.

Explorations into the specific nature of architects and the architectural practice in connection to the query strategies addressed by the developers indicate reasons for the existence of these problems. The argument for applying CBR in architecture that it is not prone to the knowledge acquisition problem is based on the classification of architectural design as a weak theory domain. However, theory states that a successful application of CBR in any domain can only be achieved when cases accumulate during the course of the regular production process (Main et al. 2001). This is not the case in architectural design. All systems and concepts reviewed rely on cases from 'second hand'. That means that others but the designing architects have to collect cases and feed these into the data bases.

Problem area 3: Method and its application to computer systems in architecture

It became apparent that:

- New mechanisms which support the accumulation of new cases are addressed only hesitantly.

The support of knowledge acquisition on the software side is addressed only disappointingly. Fuzzy Logic, Neuronal Networks or Genetic Algorithms, successfully applied in other areas, are not yet applied to design support systems at all. Growing importance only showed Data Mining Technologies in the support of learning processes in the widest sense.

- Difficulties in deciding on which cases will become part of the data base and on how to address selection procedures became apparent.

Omnipresent is the desire to exclusively provide outstanding architectural objects in CBD systems in architecture. Completely unaddressed remain thereby questions like which quality measures and which set of quality criteria need to be applied in evaluating and selecting cases.

Furthermore:

- The aspect of quality of cases is closely connected to the three different views on CBR identified earlier.

For systems which follow model and method stringently and thus experiential knowledge plays the centre role as the main source of knowledge, the discussed desire proves obsolete.

Recommendations for future research

By means of the chosen scientific approach two major directions in need of action could be identified:

- The optimization of query strategies;
- The addressing of critical aspects in knowledge acquisition in CBD systems in architecture.

To begin with one has to give the general recommendation that findings from the field of Experience Management are made to be accessible for the field of architecture, to explore their validation and check their transferability. This recommendation is based on the finding that previous CBR research almost exclusively focused on the advancement of technological aspects. Factors such as the user and the organization remained totally unconsidered.

Furthermore the recommendation is given that a systematics to formalize experiential knowledge in architecture needs to be developed. Thereby it has to be investigated whether it proves possible to find an analogy for the tripartite structure of a case integrated in the theory. One aspect in exploring this question is to make statements concerning the granularity of experiential knowledge in cases provided.

In addressing the knowledge acquisition problem two approaches come into question regarding the technical implementation:

- Strategy 1: Use of CBD Systems in architectural firms, gathering cooperative knowledge in a 'Corporate Memory' data base.
- Strategy 2: Formation of a web-based 'Collaborative Memory', where participation and sharing of experiences happens on a voluntarily basis.

In facing the knowledge acquisition problem the following recommendation is given:

- Sources of experiential knowledge in architecture need to be made accessible.

This recommendation is based on the finding that in the architectural practice indeed first, although hesitant steps can be recorded to contain experiential knowledge. However this is not conducted in a formalized way and therefore it is not of universal use.

Another recommendation is based on the fact that till today it remained unaddressed and therefore unresolved whether it is possible to access the quality of an architectural solution to maintain and provide this piece of information as part of a case:

- Ways to integrate evaluative components in case descriptions need to be discovered.

To improve accessibility of cases in data bases (query strategies), based on the findings mentioned above, the following three suggestions are derived:

- Mechanisms supporting random findings and vague queries are to be developed;
- Sketch based query mechanisms are to be addressed and
- Mechanisms to support automatically activated problem oriented queries as well as user initiated problem oriented (sketch based as well as keyword based) queries are to be developed.

The closing recommendation is based on the finding that three equal views on CBR in architecture do exist and, as showed through the investigations, rightly so:

- Systems need to allow for certain variability in their approach.

Conclusion

To sum up, the main factor for the limited success of CBR systems in architecture can be seen in the disregard of the theoretical and sociological context. Based on this fact, problems arise which are connected to the accessibility of knowledge provided in the data bases and knowledge acquisition. Particularly the addressing of the last aspect is crucial but essential for the success or failure of the intent to apply CBR to Design Support Systems in architecture.

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