Extending the Flexibility of Case-Based Design Support Tools
A Use Case in Architectural Domain

Viktor Ayzenshtadt[1,2], Christoph Langenhan[3], Saqib Bukhari[2], Klaus-Dieter Althoff[1,2], Frank Petzold[3], Andreas Dengel[2,4]

[1]*Institute of Computer Science, University of Hildesheim, Germany,* [2]*German Research Center for Artificial Intelligence (DFKI), Kaiserslautern, Germany*
[3]*Faculty of Architecture, Technical University of Munich, Germany,* [4]*Department of Computer Science, Technical University of Kaiserslautern, Germany*

PROBLEM DESCRIPTION

MetisCBR is a distributed case-based retrieval engine for search for similar designs during the early conceptual design phase in architecture. It has a number of basic retrieval strategies implemented, however, these strategies do not have a structural definition according to architectural requirements. For further research, we want to extend MetisCBR to a process-oriented case-based design support tool. Thus, we need such a structural definition to provide a common interface for implementation of different high- and low-level processes (such as retrieval strategies).

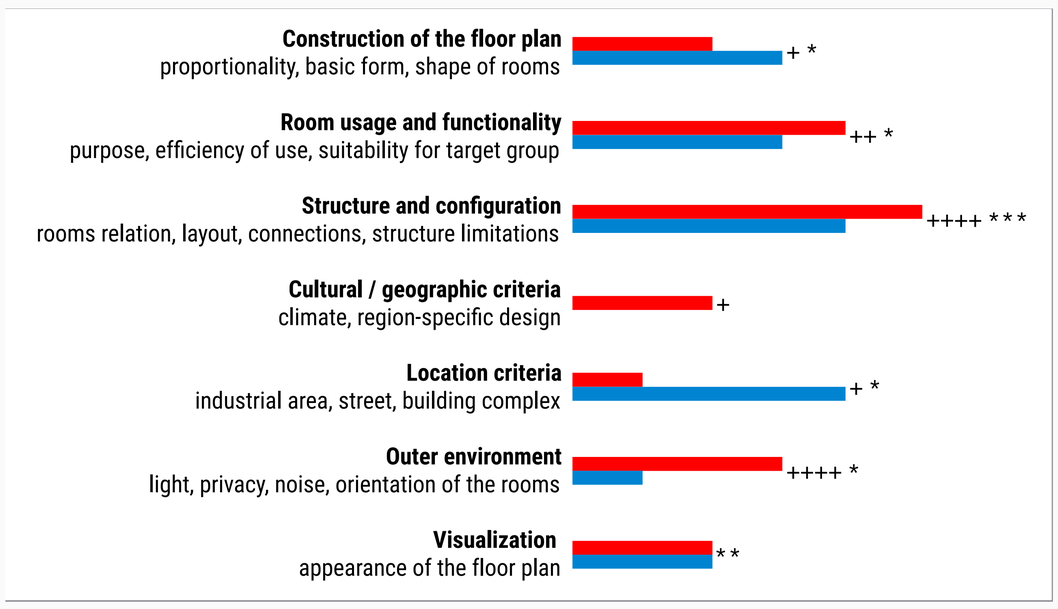
OUR SOLUTION

We assume that the best solution for strategical improvement of our system is to make use of expert knowledge from the target group, that is, the representatives of the architectural design domain. To gain this knowledge, we conducted a study where the representatives played the role of the system, i.e., were assigned with task of searching for similar architectural designs in a case base of such designs for several queries. The participants should then reconstruct their retrieval strategy and also provide a sketch of the early conceptual design phase that includes this similarity assessment.

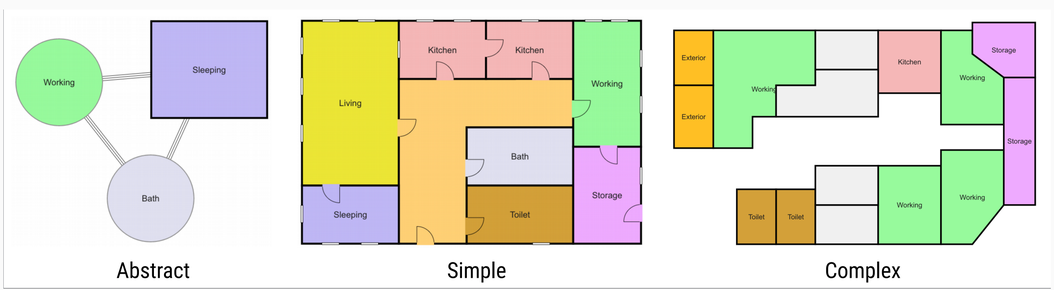
METHODOLOGY

Our methodology for conducting of the study consisted of four main phases:

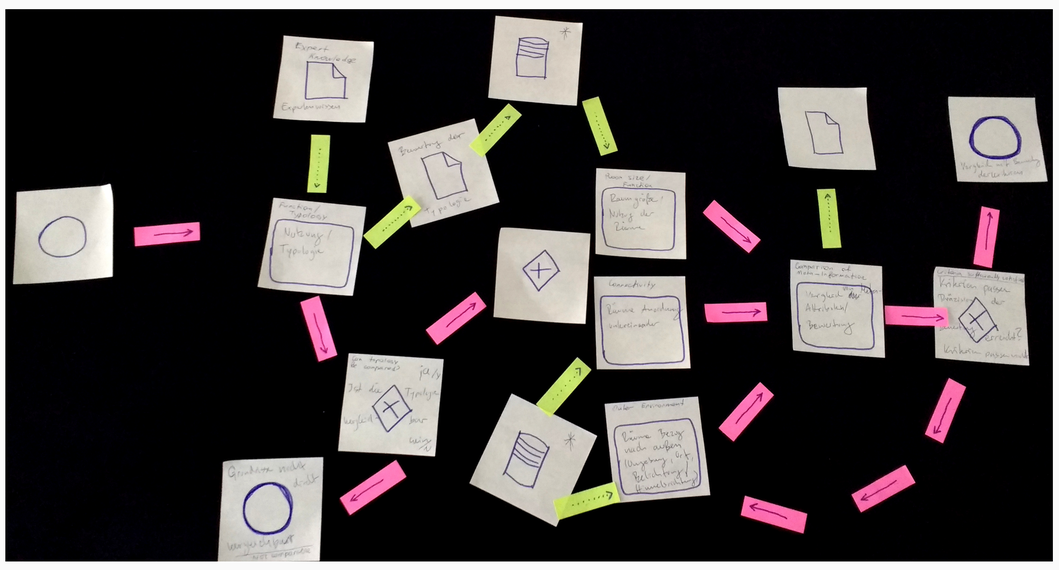
1. Building Design (Floor Plan) as a Case: Criteria Survey: The participants were asked to name the criteria for rating the quality and similarity of architectural designs.
2. Similarity Assessment Modeling: The participants were asked to manually select the most similar design(s) from a printed collection of designs for a number of queries of different complexity. After the selection they were asked to reconstruct their cognitive similarity assessment process using the sketched BPMN prototypes.
3. Conceptualization Process Modeling: The participants were asked to model their entire (early) conceptualization process, including the similarity assessment.
4. Cross-Evaluation: The current participant was asked to evaluate the similarity assessment process of one of the previous participants.



Phase 1: the length of the lines indicates how often they were mentioned as quality criteria (red) and as similarity criteria (blue). [+] indicates the *key criterion* frequency, [*] is the *flexible criterion* frequency.



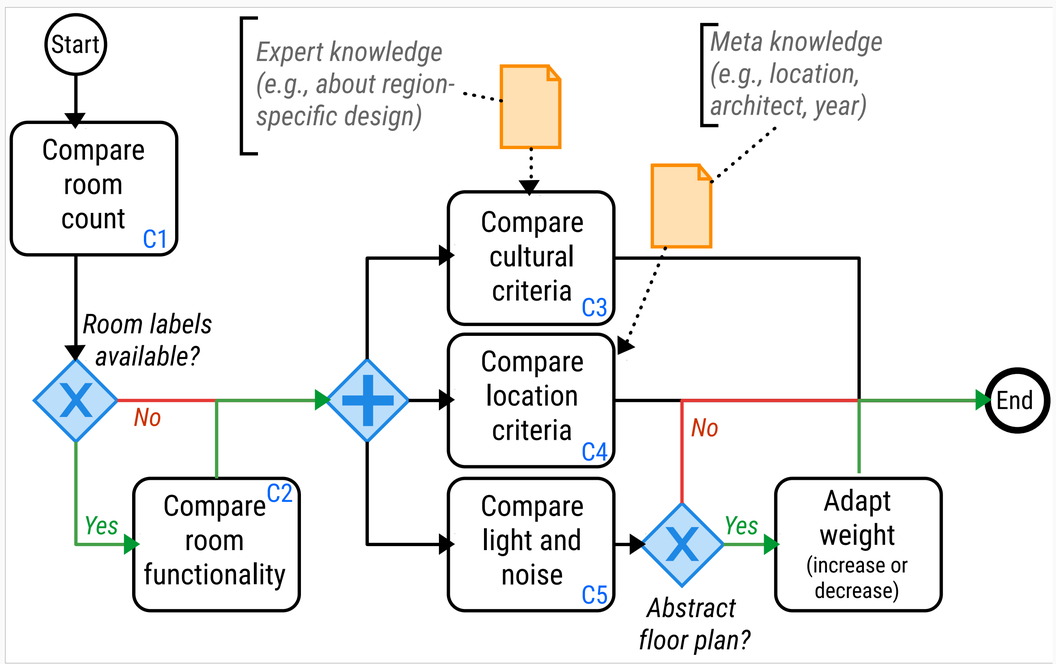
Different complexity levels of the queries and cases used in the similarity assessment phase of the study.



A similarity assessment process of one of the participants modeled with sketched BPMN elements.

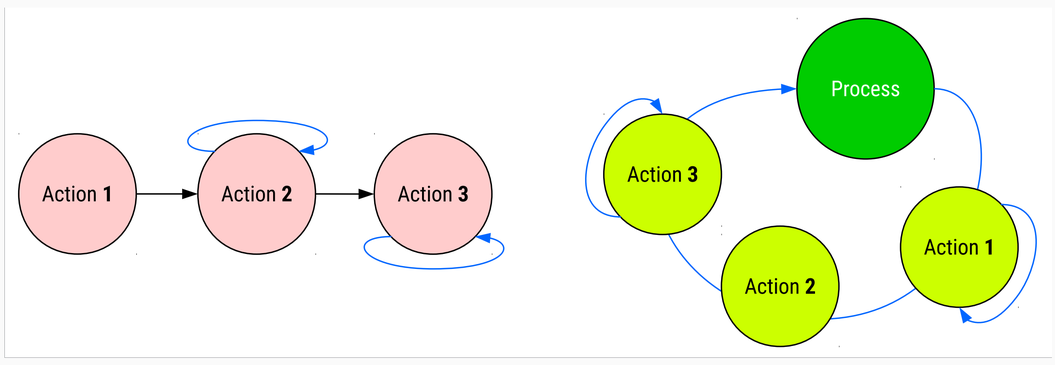
DEFINITIONS INFERRED FROM THE STUDY

Strategy *is a quadruple* $S = (C, K, \mu, F)$*, where* C *is criteria,* K *is knowledge,* μ *is similarity measure, and* F *is flexibility.* $C = C_s \cup C_d$ *(criteria can be of dynamic and static type), where* $C_s \vee C_d \neq \varnothing$*.* $K = K_m \cup K_e$ *(meta knowledge about the cases in the case base and expert knowledge in the domain, e.g., in architecture), where* $K_m \vee K_e \neq \varnothing$*.* $\mu = \mu_s \cup \mu_p$ *(similarity measures can be of parallel or sequential type), where* $\mu_s \vee \mu_p \neq \varnothing$*.* $F = (f_c, f_\mu)$*, where* f_c *is the value of the strategy's flexibility that corresponds to the criteria and* f_μ *is the value for the conditional variability of* μ*, i.e, the variability of the similarity value's conditional values (such as weight or degree) under certain constraints (e.g., different complexity levels of the floor plan).*



An exemplary strategy that satisfies all of the requirements named in the definition. Here, C1 and C3-C5 are the static criteria that are always applied as comparison criteria. C2, however, is a dynamic criteria that depends on the availability of room labels, i.e., functions. Expert and meta knowledge help to resolve the comparison of C3 and C4. C1 and C2 are resolved with sequential similarity measures, i.e., C2 follows C1. In contrast, C3-C5 are resolved with a parallel type of similarity measure (e.g., with agents that work concurrently and then apply weights and calculate an amalgamated similarity value out of these three). Assuming, we have applied $f_c = 0.6$, we get a flexibility that 3 of 5 criteria should be at least sufficiently similar for a floor plan to be considered for inclusion in retrieval results, where the weight of similarity value of C5 depends on the complexity of the floor plan (alternatively, C5 can be defined as a dynamic criterion with complexity of floor plan as its condition).

Process *is a triple* $P = (S, t, A)$*, where* S *is a set of strategies as defined in Definition 1,* t *is the type of the process (e.g., sequential, semi-sequential, enclosing iteration), and* A *is the set of actions.* $A = A_s \cup A_i \cup A_e$ *(actions can be of starting, ending, and intermediate type), where* $A_s \wedge A_e \neq \varnothing$*. Strategies are linked to actions with a surjective mapping* $S \twoheadrightarrow A$*, i.e.,* $\forall a \in A \exists s \in S$ *(for each of the strategies at least one action exists that this strategy is mapped to).*



Different types of processes. 1: sequential with a number of subsequent sub-processes, where some of them are of iterative type. 2: an enclosing iteration that consists of sub-tasks, which can also be iterative.

Email: Viktor.Ayzenshtadt@dfki.de
Web: http://dfki.de/web/forschung/km/projekte
http://ksd.ai.ar.tum.de