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

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PROBLEM DESCRIPTION

Metis\textsuperscript{CBR} 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 Metis\textsuperscript{CBR} 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).

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 rate the criteria for naming 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.

OUR SOLUTION

We assume that the best solution for strategic 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.

DEFINITIONS INFERRED FROM THE STUDY

Strategy is a quadruple $S = (C, K, \mu, F)$, where $C$ is criteria, $K$ is knowledge, $\mu$ is similarity measure, and $F$ is flexibility. $C = C_1 \cup C_2$ (criteria can be of dynamic and static type), where $C_1 \cup C_2 \neq \emptyset$, $K = K_\text{min} \cup K_\text{max}$ (meta knowledge about the cases in the case base and expert knowledge in the domain, e.g., in architecture), where $K_\text{min} \cup K_\text{max} \neq \emptyset$. $\mu = \mu_1 \cup \mu_2$ (similarity measures can be of parallel or sequential type), where $\mu_1 \cup \mu_2 \neq \emptyset$. $F = (f_c, f_p)$, where $f_c$ is the value of the strategy's flexibility that corresponds to the criteria and $f_p$ is the value for the conditional variability of $\mu$, 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 $f_p = 0.6$, we get a flexibility of 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. $A = A_\text{start} \cup A_\text{end} \cup A_\text{inter}$ (actions can be of starting, ending, and intermediate type), where $A_\text{start} \cup A_\text{end} \neq \emptyset$. Strategies are linked to actions with a surjective mapping $S \rightarrow A$, i.e., $\forall a \in A_\text{start} \exists s \in S$ (for each of the strategies at least one action exists that this strategy is mapped to).

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