Conceptual Blending in Case Adaptation (Position Paper)

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Abstract. We propose that Conceptual Blending (CB) can play a role within the Case-Based Reasoning (CBR) paradigm, particularly in the *Reuse* and *Revise* tasks of the classic model of the problem solving cycle in CBR, as an alternative adaptation mechanism that may provide suitable solutions in computational creativity setups, where novel and surprising solutions are sought. We discuss how a particular computational implementation of CB can intervene in the CBR cycle, and use the results of an experiment made in the past to illustrate the aproach. We focus our attention on graph-based structured cases. Other case representations could also be considered in the future.

1 Introduction

The Conceptual Blending (CB) theory [3] intends to explain several cognitive phenomena related to the creation of ideas and meanings. A key element in this theory is the *mental space*, which corresponds to a temporary and partial structure of knowledge built for the purpose of local understanding and action. The CB framework relies on a network comprised of at least four connected mental spaces (Figure 1). Two or more of them correspond to the *input spaces*, which are the initial domains, i.e., the content that will be blended. Then, a cross-space mapping, i.e., a partial correspondence between the input spaces, is established. The correspondences between elements of the different input spaces is not arbitrary; elements are only matched if they are perceived as similar in some way. This association is reflected in another mental space, the *generic space*, which contains elements common to the different input spaces, capturing the conceptual structure that is shared by the initial mental spaces. The result of the blending process is the *blend*, a new mental space that maintains partial structures from the input spaces, combined with an emergent structure.

In this position paper, we propose that Conceptual Blending can play a role within Case-Based Reasoning, particularly in the *Reuse* and *Revise* tasks of the classic model of the problem solving cycle in CBR, known as the “4 REs” [1], as an alternative adaptation mechanism that may provide better solutions in computational creativity setups, and possibly also for problem solving. We will focus our attention on graph-based structured cases (like in [7]), but we think the approach could also be adapted to other case representations [2]. To better

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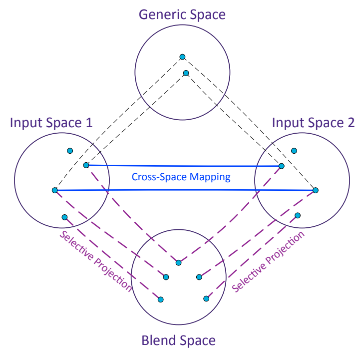

Fig. 1. The original four-space conceptual blending network [4].

explain our idea, we will use an implementation of the CB mechanism called Divago [6], previously developed by our team.

After the current introduction, we will briefly describe Divago in Section 2 and present our proposal in Section 3. In Section 4 we draw some conclusions.

2 Divago

The CB framework has served as the basis for several artificial creative systems. To discuss the role of CB within the CBR cycle, we focus on the Divago architecture [6], which relies on one of the most thorough and detailed computational models of CB to date.

The Divago framework works on a multi-domain knowledge base where the basic representation formalism is the *concept map*, a semantic network that denotes the relationship between the concepts of a given domain. It is composed of several modules (Fig. 2) that reflect the different stages of the CB mechanism.

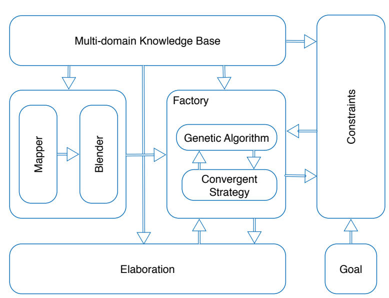

Fig. 2. Divago's architecture.

The process starts by feeding a pair of input spaces (domains) from the knowledge base into the *Mapper* module, which is responsible for performing the selection of elements for projection. Such selection is achieved by means of a partial mapping between the input spaces using *structural alignment*. This operation looks for the largest *isomorphic* (structurally equivalent) pair of subgraphs contained in the input spaces. Each mapping is a set of mapping relations $m(x, y)$ between two concepts, one of each input space.

For each resulting mapping, the *Blender* module performs a projection operation into the blended space: for each $m(x, y)$ in the mapping, it produces a nondeterministic projection choice between x, y, $\emptyset$ and $x|y$ (which means *both* x *and* y); each combination of choices is the *seed* of a possible blend (to be completed and elaborated in the next stages). This process results in a graph structure (the *blendoid*) that includes all projection choices and thus represent the search space for all the blends that may result from the mapping.

The *Factory* module is responsible for exploring this search space. It is based on a variation of a genetic algorithm (GA) that uses the *Elaboration* module to enrich blends with additional knowledge and the *Constraints* module to assess their quality. This module provides an implementation of the *optimality principles* (a set of principles that ensure a coherent and highly integrated blend [3]). When an adequate solution is found or a pre-defined number of iterations is attained, the Factory stops the execution of the GA and returns the best blend. The *Constraints* module acts, thus, as the "fitness function" of the algorithm.

3 Conceptual blending in case-adaptation

The classic model of the problem solving cycle in CBR, known as the "4 REs", comprises 4 tasks: *Retrieve*, *Reuse*, *Revise* and *Retain* [1]. In the core of the process lies a *case base* of stored past experiences, each one of them comprising a problem description and the respective solution.

Although cases can be represented in many different ways [2], we will consider the situation where a structured representation is used, like for instance [7]. In particular, we will assume that there are *relations* between *attributes*. Some of them allow for hierarchical organisations (e.g., *isa* and *partwhole*), others induce a network structures (e.g., *purpose*, *shape*, relations for relative position). Table 1 describes, using a Prolog-like notation, a fragment of a case for a "House", where such relations occur. The right column is a partial description of the attribute/value pair part of the same case.

Coming back to the "4 REs" cycle, the reasoning process starts with a new problem specification being given to the first task, *Retrieve*, which seeks for stored cases with similar problem descriptions, using some similarity criterion. The result is a list of retrieved cases, of which one can be selected as having the most similar problem description to the given problem. In the general case, the similatity is not absolute and differences with the given problem description exist. This requires that the retrieved case is subject to some sort of adaptation in the task *Reuse*, trying to compensate for the differences with the given problem description. *Revise* will be responsible for evaluating the quality of the result.

Table 1. Fragment of the "House" case.

isa(house,physical_structure)	part_whole(door, house)	instance_of(r1, roof)
isa(door, physical_object)	part_whole(window, house)	instance_of(b1, body)
isa(window, physical_object)	part_whole(roof, house)	instance_of(d1, door)
isa(roof, physical_object)	part_whole(body, house)	instance_of(w1, window)
isa(body, physical_object)	part_whole(room, house)	shape(r1, triangle)
isa(observation, task)	purpose(body, container)	shape(b1, square)
isa(protection, task)	purpose(door, entrance)	shape(w1, square)
isa(entrance, task)	purpose(window, observation)	
isa(container, physical_object)	purpose(roof, protection)	

Now, let us assume that the retrieved case, c_r, is the one described in Table 1. This might happen, for instance, if the case base was composed of descriptions of houses, the problem to solve was to find a house description according to a given specification and the specification of c_r was the most similar to the given one. Let us also assume that we are in a creative setup, where we want to find ideas for houses that, although satisfying the specification, are novel and surprising. Our proposal is to seek for surprising solutions by processing the adaptation through *blending c_r with knowledge from a different domain*. The result will be a case that shares part of its description with the retrieved case, but includes contributions from the other domain. Such contributions may, for instance, fill existing gaps in c_r, substitute part of its structure, etc. As we will see, the result may be more or less *divergent* from the original domain of "houses" according to how we control the blending process and "how far" from "houses" the other domain is. The domain to use in this process may be chosen by the user, or may result from a contextual analysis whose discussion is outside the scope of this paper. We argue that Divago can deal with the process in a suitable way.

To illustrate our proposal, we re-visit the experiment described in [5], where the blend of two domains, "boats" and "houses", is explored using just the modules *Mapper* and *Blender* of Divago, with the aim of studying their *generation potential*. The situation is very similar to the one described in the previous section, as c_r, the "House" case, can be seen as an instance of the original "houses" domain. With this analysis, we intend to illustrate how the "House" case can be merged with the domain "boats".

In the experiment, the *blendoid* resulting from the most frequent mapping represents a wide variety of instances for "boat-house". We show six of them in Figure 3, where the visual representation of c_r is shown on the left.

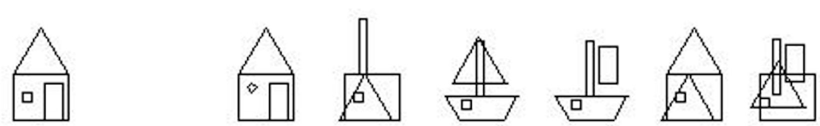

Fig. 3. The retrieved "House" case and six possible blends with the "boat" domain.

We can see that the weight of the "boats" domain in the blends varies a lot. The *divergence* of the blends from the stereotypical description of a Boat and from c_r also varies a lot, from a house with a hatch instead of a window to a house with a sail instead of a door and a mast instead of a roof.

In Divago, the GA-like search for blends is guided by an implementation of a variation of the "optimality principles" proposed in the CB theory, which favours the coherence of the resulting blends. In the context of this proposal, however, a metric for the similarity with the original problem specification should also be taken into account, and possibly assume a prevailing weight in measuring the quality of the blends.

4 Conclusions

We argued that Conceptual Blending, and in particular its computational implementation Divago, can provide an alternative adaptation mechanism for the *Reuse* and *Revise* tasks of the classic CBR model. The idea is to *blend* the case selected in the *Retrieve* task with knowledge from a different domain. This may prove especially effective in computational creativity contexts, where it may provide an iterative divergence mechanism coupled with evaluation. The criteria for evaluating each possible blend may combine measures of coherence with measures of distance to the given problem specification. This is a preliminary proposal in the context of a Position Paper. Definitely, further research is needed to understand its limits.

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