Compositional Adaptation in Case – Based Reasoning based on the Semantic Relations between the Components in the Cases

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***Abstract*—In this paper, an approach has been proposed for compositional adaptation of the cases based on the semantic relations between the components in each case. Within this scope, a problem situation comprising some components with semantic nature operates over the stored cases to make a reasonable use of the related components and the corresponding similarities with its own components. In this regard it would be necessary to figure out first how the components in the stored cases can be regarded similar to those in the problem situation and then take into account the very relations which are considered between the components in these cases. To provide such types of information, ontological structures developed for specific problem domains, including properties or characteristic the components as relations, are of particular significance. The suggested approach is particularly effective for design purposes where designing an artifact may call for combining a variety of cases each meeting some important constraints in some way.**

Keywords— Case – based reasoning, compositional adaptation, semantic relation, additional fact, case component, semantic similarity, problem situation, complementary components.

I. INTRODUCTION

Compositional Adaptation has been widely used as an approach to case adaptation in case based reasoning to provide reasonable solutions in the cases where the current problem situation is in practice similar to a variety of cases, thus making case adaptation often turn to a serious problem. There are generally two problems with compositional adaptation: (i) retrieving those cases which can meaningfully participate in the process of adaptation, and (ii) lack of transparency with regard to the utility of the adaptation format in providing a reasonable final solution.

Although a variety of mathematical formats based on using similarity functions have been proposed to assess the similarity between a problem situation and the situations in the stored cases, they are not however adequate in the situations where the propositions stating a problem situation have strong semantic nature. To circumvent such a problem, representation of a case should tend to a format that can be benefited by knowledgeable relational structures between its components. In this way efforts are to be made to consider the semantic relations between the components as a part of representation for the cases, and in the meantime take into account the semantic similarity between the components of a problem situation and those belonging to the stored cases. In this way, one may expect that a broader range of cases can take part in adaptation process providing a chance for a problem situation to take advantage of different alternatives to shape the final solution in a more reasonable manner. It should however be noted that no guarantee exists to obtain a fully satisfactory solution in this way, due to the point that situations experienced in the past may not theoretically be adequate for tailoring solution for the entire problem situations in future. However the major advantage of such an approach is its capability in optimal utilization of these cases, with the aim of deriving an optimal final solution.

II. SOME EXISTING APPROACHES IN COMPOSITIONAL ADAPTATION

The main concern in compositional adaptation is to combine a variety of cases, similar to a problem situation, to produce a new composite solution which can best fit this situation [arabnia5,6,7,8,9,10,11,12,13,14,15,16]. Compositional adaptation can be applied into two different situations.

a) The situation where the solution of a case consists of a variety of components different is nature, and each component has the ability to be adapted in an appropriate manner. This view is supposed to be effective in the situations where the components do not held much (or serious) conflicts with each other [arabnia 1]. For instance, Prodigy / Analogy is a system which can construct a new solution from a set of mediating cases as supposed to a single stored case, Here, complex cases can be solved through retrieving minor interaction among the simple cases stored in the library [arabnia 9]. Within this scope an approach has also been proposed which performs a knowledge intensive template

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selection during the process of generating a text belonging to a story [gerves 6].

It is worth mentioning that the conflicts coming out here between the components can be considered in terms of some situations whose removal itself may need another process of case based reasoning. Regarding this, one may notice that the adaptation method can be performed in a recursive way to shape finally a solution with least amount of conflict between the corresponding components. Obviously, the less number of recursions, the more favorable the considered adaptation method is supposed to be.

b) The situation where the solution is not dividable into independent components and thus the solutions belonging to the cases which are similar enough to the problem situation should be combined in some way. In the Airquap whose function is to predict levels of pollution, the solution is determined through calculating the average value of the solutions belonging to the most similar cases in the library [arabnia 5]. Regarding this, the final solution would be an overall combination of the participated situations taking into account the normalized similarities of the related situations [arabnia 6]. Such a combination can be regarded a sort of fusion according to which the overall uncertainty of the resultant solution is expected to be less than the uncertainty belonging to each individual situation. Obviously the more distant the expected uncertainty of the resultant solution from these individual solutions, the more favorable such a fusion is supposed to be. With regard to this perspective, an approach has also been proposed which makes use of a kind of information regarding the correspondence between the components in a solution, and the major components in the problem situation [arabnia]. Having represented cases situations in terms of some graphs comprising certain components (as nodes) and the relations between them, the solution graphs belonging to the similar cases are merged through a process of inexact matching to specify in which way the constraints defined for the nodes and their relations can be met satisfactorily. With regard to the situation where solutions are not dividable into independent components, an approach has also been proposed which composes recipes of foods using workflow systems based on the idea of covering the missing parts of retrieved cooking workflows using information from other cases [graves 7]. In contrast with the other approaches to compositional adaptation, the two approaches discussed above [arabnia, graves 7] have the ability to control over the way a solution is formed thus making it as reliable as possible.

III. The Proposed Framework

A. Basic Idea

A prime aspect of analogical reasoning in general and adaptational analogy in particular, is to provide required additional facts for a problem situation based on the cases stored in the library. A noticeable point here is that, in many cases the components of the problem situation and those in the stored cases are entities with different semantic nature thus making the issue of case adaptation rather problematic. Based on this point, it would be necessary to make use of different cases within each some components may exist that can contribute to the problem situation in some way. Possibility however exists that the components chosen from different cases may in reality be incompatible with each other thus increasing the risk of leading ultimately to a non – reasonable solution. To overcome such a problem, considerations with regard to certain constraints are required to assure the validity of a solution at different stages of its formation. Such considerations are supposed to be included in the structure of the cases once they are stored in the library. Based on the idea discussed above a framework is proposed, according to which a problem situation comprising some components with semantic nature operates over the stored cases to make a reasonable use of the related components and the corresponding similarities with its own components. Within such a process it would be necessary to figure out first how the components in the stored cases can be regarded similar to those in the situation and then take into account the very relations which are considered between the components in these cases. To provide such types of information, ontological structures developed for specific problem domains, including properties or characteristics o the components as relations, are of particular significance. Such types of ontology, though hard to be provided, are quite helpful in the situations where the components included in a problem situation can be regarded similar to those in the stored cases based on their shared properties or characteristics belonging to a certain domain. Such considerations are in fact capable of identifying those components in the stored cases that are worth being transferred to the problem situation as the complementary components, and deleting those irrelevant options that are not compatible with the requirements of the problem situation. In this way they have the potential to reduce the amount of search over the existing cases which is for sure essential to configuring a reasonable final solution. It should however be noted that, to keep the final solution as optimal as possible, only one component from each case ought to be added to the problem situation. Figure1 and Figure 2 illustrate representatively the phases essential to our approach and the corresponding flowchart.

Phase 1: Determine which components in the pre- stored cases can be semantically similar to the components in the problem situation taking into account their shared properties, characteristics or the categories they belong to.
Phase 2: See which of these categories, shared properties or characteristics are to be regarded as constraints taking into account specialized knowledge.
Phase 3: See, out of the components in the pre–stored cases, which components may help the constraints be satisfied due to their relations with the components discussed above (provided that no component exists in the problem which can achieve their role.)
Phase 4: Transfer the components identified in phase 3 (complementary components) to the problem situation taking into account the point that, with regard to each constraint, only one component ought to be added to the problem situation.
Phase 5: Fix the possible alternatives for the final solution.

Fig. 1. Phases essential to the proposed approach

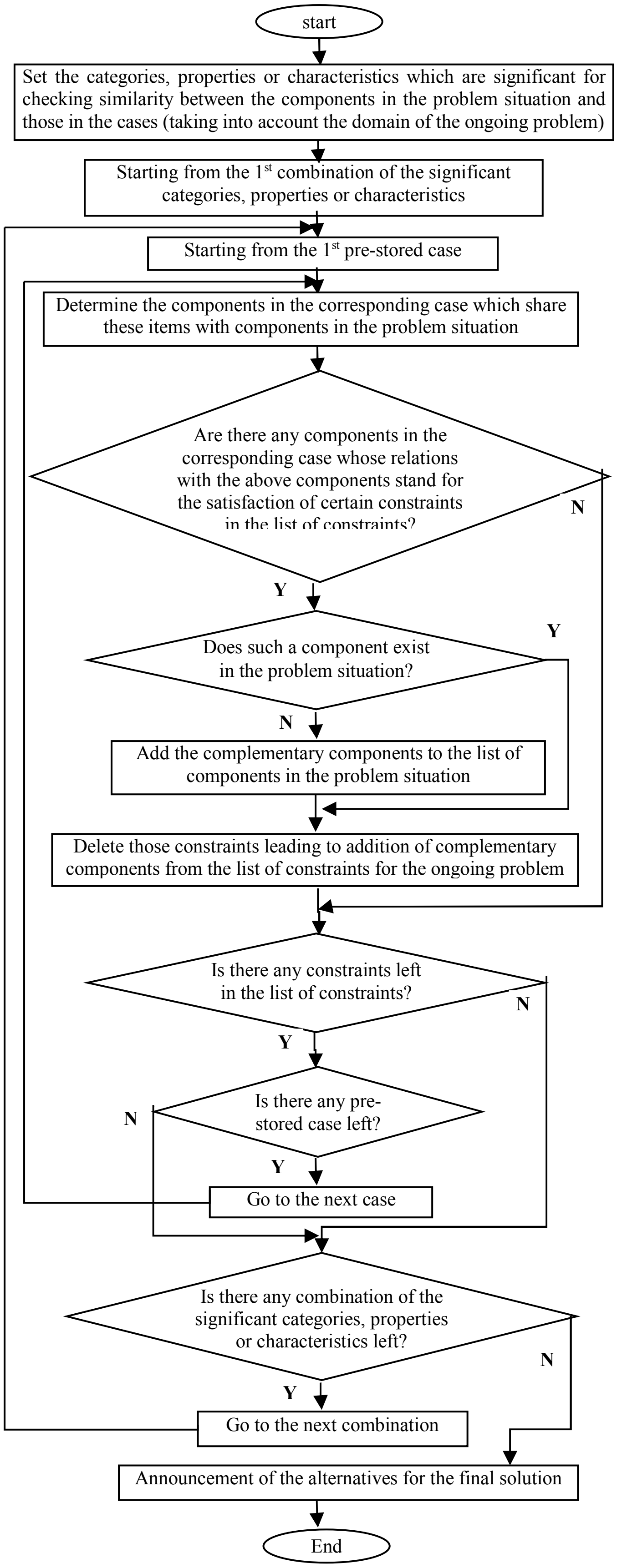

Fig. 2. The flowchart for the proposed approach

As it is seen from this framework, all the cases which are somewhat relevant to the current problem situation have the opportunity to take part in forming the final solution each based on its own potential. In this way, the proposed framework is regarded to belong to the second group of approaches discussed in II, where the final solution is supposed to be an overall combination of the participated situations taking into account the contribution of each case from the viewpoint of its similarity with the current problem situation.

IV. AN EXAMPLE

Suppose that the problem is to configure some added supplements for a dish of sandwich including "eggplant" mixed with "whey" as the favorites of its customer. This means to see whether based on the content of some pre-stored cases, we may find some additional components that can be complementary to the dish, making it more favorable while taking into account a number of constraints. These pre – stored cases are expected to be similar to the problem situation in some way.

Figure 3 shows three pre-stored cases that have such a characteristic. As it is seen from these cases, each case contains some components with different semantic nature together with some extra information regarding the relations between them. For instance, it is known that "baguette fits the taste of roast beef", where "mint makes favorable the taste of roast beef". (Figure3 (I)) In the meantime experience shows that "thin bread fits the moisture of mince meat", while "onion fits the taste of mince meat". (Figure3 (II)). Since the components included in these cases and the problem situation are in general semantically different, a framework is required to determine which components in them can be regarded similar to those in the problem situation. Taking this point into account, two components are supposed to be similar to each other, if a characteristic or property exists shared by both. Obviously, based on the status of this characteristic or property, different formats of similarity would come true. In the above example, "fat", "moisture", "smell" can be examples for such a property or characteristic. As it is seen from the figure, "fat" is a property shared by "roast beef", "mince meat" and "round meat" in cases 1, 2 and 3, and in the meantime "whey" in the problem situation. Meanwhile, "moisture" is a property which is shared by "mince meat" in case 2 on the one side and "eggplant" in the problem situation on the other side. Having considered such points, the important point at this stage would be to see which further components in these cases can help satisfy the very constraints which in reality exist with regard to "eating".

Since all "fat", "moisture" and "smell" are supposed to be so, it should be checked then which components in the cases can take such a role. It is seen that "thin bread" (in case 2) and "mint" (in case 1) have such an ability, but no component exists in neither of the cases that can satisfy "fat" as a constraint. Conclusion is that "mint" and "thin bread" respectively selected from case1 and case 2 are to be added to the structure of the sandwich as added supplements shaping the final solution of "sandwich comprising thin bread (as bread), egg plant, whey and mint". It is however to be noted that possibility exists that "fat" may be problematic since no component can be systematically derived from the existing cases that can have reasonable solution for it. One can in this way expect that the final information (to be added to the problem solution) may be organized in a way that problem-solver may know which constraints out of the existing ones, have been satisfied within the entire process of compositional adaptation and due to which reasons. Of course, it is possible that different configurations may be proposed as the final solution since there is no guarantee that a solution comprising components from different cases itself would not end up new constraints caused by co-presence of these components. Also, no guarantee exists that a unique solution can meet the entire constraints simply because of lack of sufficient knowledge in the stored cases.

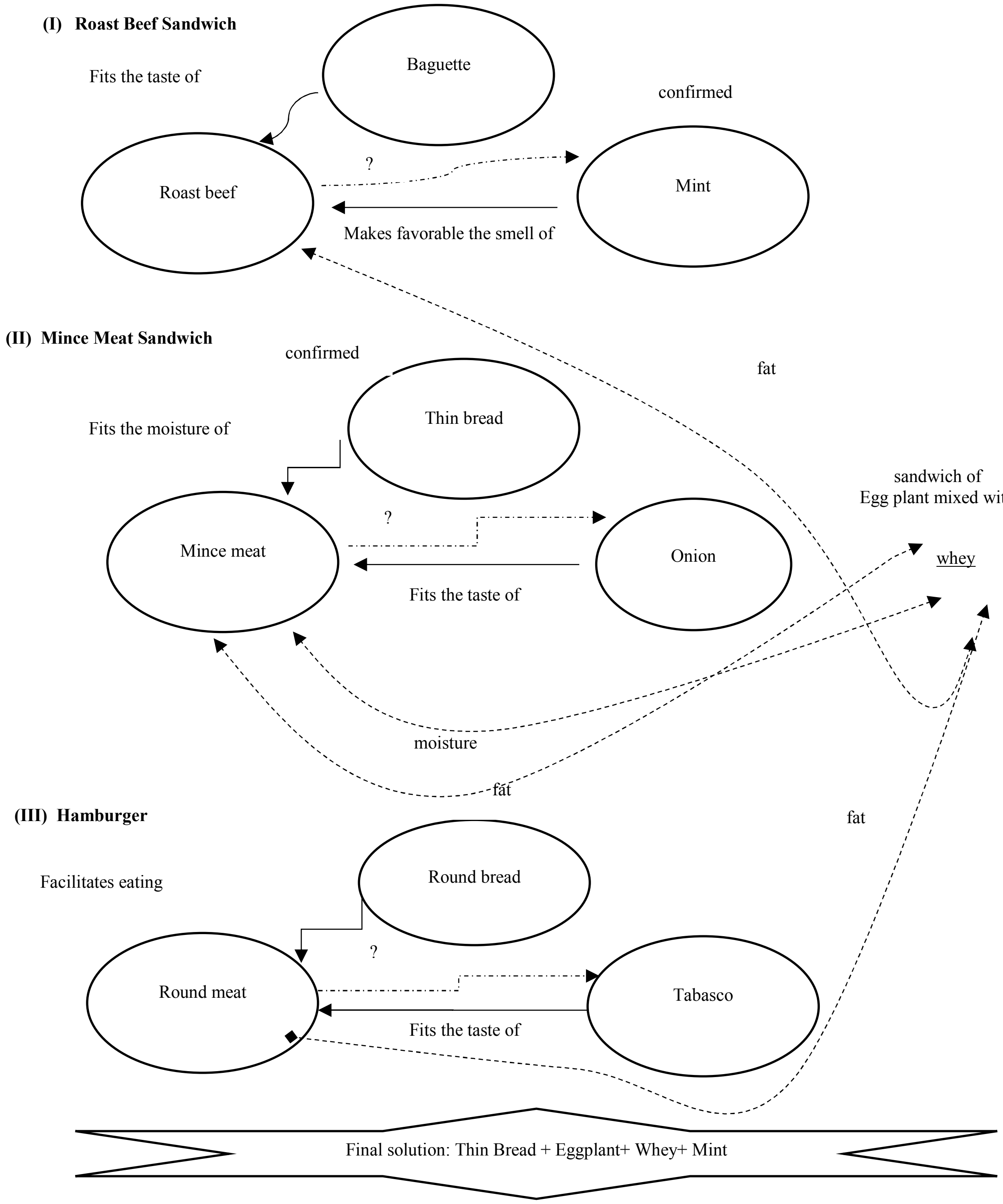

Fig. 3. An example for compositional adaptation of cases for making a final dish

V. SCOPE OF APPLICATION FOR THE PROPOSED APPROACH

The proposed approach is particularly helpful in designing an artifact based on combining a variety of cases each including a number of components with a number of considerations tackling specific constraints as the relations between these components. Regarding this, once a problem of design is propounded addressing the design request including the constraints to be met and the knowledge regarding the components to be observed in the desired artifact, the compositional adaptation format elaborated in our approach, would have the ability to compose the relevant cases in a way that the constraints can be met in a satisfactory manner. Examples can be mentioned for designing items such as an apparatus, architecture of a house, a treatment regime (in hospitals or clinics), a content (for education, planning or research purposes), a menu or a dish of food (to be served in restaurants or banquets), and a dress or a garment (for a special occasion or ceremony). In all these situations, composing the knowledge encapsulated in the pre – experienced cases based on the idea of constraint satisfaction in the way discussed in this paper, has the potential to make the final solution as reasonable as possible.

VI. CONCLUDING REMARKS & FURTHER DISCUSSION

The compositional adaptation approach proposed in this paper has the potential to make use of the components included in different cases based on their similarities with the components in a problem situation to tailor the final solution in such a way that the constraints presumed for a problem can be met satisfactorily. To meet such constraints, a variety of semantic considerations regarding the relations between cases' components are taken into account with the aim of assuring the validity of a solution at different stages of its formation. Such relations are in practice responsible for justifying the appropriateness of a case with regard to its problem situation and are thus helpful for mentioning the status of validity with regard to intermediate results in adaptation. A particular point in our approach as discussed in the paper, is the way similarity between the components in the problem situation and those in the stored cases is assessed based on their categories, or shared properties or characteristics. Taking this point into account different alternatives may be regarded similar to the components in the problem situation. This provides a suitable chance to bring into attention a variety of pre – experienced cases that can take part in tailoring the final solution. In this way opportunity exists to select out of these final solutions the one which is most promising.

The suggested approach to compositional adaptation is particularly effective when designing an artifact calls for combining a variety of cases each meeting some important constraints in some way. Obviously, the higher the number of such pre-stored cases, a higher opportunity would exist to shape a final solution with a higher number of constraints having been met. Due to the difference in semantic nature of the components included in the cases as well as the problem situation, it is most necessary to figure out how similarity between the cases' components in problem can be justified in a meaningful manner. Ontology of specialized terms including the relations like "property" and "characteristic" was mentioned to be helpful in this regard. Such type of ontology needs to be developed separately for each domain of application as background knowledge. Developing such anontology for each domain of interest can thus be significant for realizing the suggested approach in a successful manner.

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