Experimental Evaluation of HoRIM to Improve Business Strategy Models

Abstract—**Aligning organizational goals and strategies is important in Business Process Management (BPM). The Horizontal Relation Identification Method (HoRIM), which is our extension of the GQM+Strategies framework, improves the strategic alignment between organizations. GQM+Strategies aligns the strategies across organizational units at different levels by a strategy model, which is a tree structure of strategies called a GQM+Strategies grid. HoRIM identifies and handles horizontal relations (e.g., conflicting and similar strategies) between strategies in different branches, but we have yet to adequately inspect the impact of HoRIM on identifying correct horizontal relations and improving grids. This lack of clarity hampers the application of HoRIM to industrial business strategy models. Herein we evaluate the impact of HoRIM on the review process and the improvement process of GQM+Strategies grids using two experiments. The review experiment confirms that HoRIM identifies about 1.5 more horizontal relations than an ad hoc review. The modification experiment where four researchers evaluated the validity of improved grids by the ranking method suggests that HoRIM effectively modifies GQM+Strategies grids.**

Keywords—GQM+Strategies; business strategy model; Horizontal Relation Identification Method

I. INTRODUCTION

Aligning organizational goals and strategies is important in the Business Process Management (BPM) community [1]. Balanced Scorecard [2], Enterprise Resource Planning Systems (ERP) [3], and GQM+Strategies®[1] [4][5] support such an alignment.

GQM+Strategies provides a hierarchical structure called a GQM+Strategies grid based on the organizational structure. A GQM+Strategies grid is iteratively generated by decomposing the initial goal into strategies supporting goal achievement. The grid coordinates goals and strategies across different levels. However, GQM+Strategies grids may contain horizontal relations (e.g., conflicting strategies) between strategies in different branches. However, the GQM+Strategies framework does not provide a method to identify and handle horizontal relations.

Previously, we proposed the Horizontal Relation Identification Method (HoRIM) to iteratively improve a GQM+Strategies grid [6]. To identify horizontal relations, HoRIM detects differences between the initial GQM+Strategies grid and a model obtained by applying Interpretive Structural Modeling (ISM) [7] to the initial grid. Then HoRIM provides a framework to modify the horizontal relations in a GQM+Strategies grid.

The effectiveness of HoRIM, particularly the improvement process, has yet to be thoroughly assessed, limiting the application of HoRIM to industrial business strategy models as well as the extension of HoRIM. Herein we study the impact of HoRIM on the review process and the improvement process compared to the ad hoc method. Our experiments address the following research questions (RQs):

- RQ1: Does HoRIM more effectively identify horizontal relations in GQM+Strategies grids?
- RQ2: Does HoRIM improve the quality of GQM+Strategies grids?

To answer the above research question, this paper experimentally evaluates HoRIM using review and modification experiments. In the review experiment, subjects identified the horizontal relations from the GQM+Strategies grid with HoRIM or an ad hoc review. In the modification experiment, subjects suggested several alternatives to modify the horizontal relations and improve the GQM+Strategies grid. Then evaluators who research GQM+Strategies ranked the improved grid.

The contribution of this paper is that we demonstrate the effectiveness of our method experimentally. The results lead to two main findings. First, HoRIM is effective in both the review process and the improvement process. Second, the evaluators cannot appropriately evaluate the strategy models when the comprehension of the background of the model is different between the evaluators and the proposer of it.

II. BACKGROUND

A. GQM+Strategies

The GQM+Strategies method is an extension of the GQM approach, which is used to create and establish measurement programs. The GQM+Strategies method also provides a

[1]GQM+Strategies® is a registered trademark (No. 302008021763 at the German Patent and the Trade Mark Office (international registration number IR992843).

hierarchical structure called a GQM+Strategies grid to align organizational goals and strategies at different levels.

A GQM+Strategies grid consists of GQM graphs [8] and GQM+Strategies elements (Fig. 1). The GQM graph monitors all goals at various levels of an organization to evaluate the achievement of each goal. The graph involves three concepts: goals, questions, and metrics. GQM+Strategies elements align goals and strategies throughout an organizational hierarchy. These elements specify organizational goals, strategies, rationales, and their relationships.

The GQM+Strategies framework creates a grid by repeatedly defining lower-level goals and strategies based on the initial set of goals and strategies. That is, the GQM+Strategies grid is specified from the initial goal, which is repeatedly decomposed to create a concrete goal. Generating a GQM+Strategies grid is three-step process. (1) Define the initial goal. (2) Specify the strategies to achieve the goal and the rationales to explain how the strategies will realize the goal. (3) Define the goals of the lower level units and return to step 2.

B. Horizontal relations

Our efforts focus on the strategies in GQM+Strategies grids. We define a vertical relationship as a parent-child relation between strategies. Although GQM+Strategies grids frequently have horizontal relations between strategies in different branches (Fig. 2), the GQM+Strategies method does not support horizontal relations.

Horizontal relations can be classified into three categories:

- Conflicting strategies, which contradict or negatively influence each other. Conflicting strategies must be identified and resolved in order for an organization to run smoothly and effectively.
- Potential contributions, where one strategy contributes to a strategy in another branch. An organization should identify potential contributions to other strategies to improve the quality of its products.
- Similar strategies, which are executed by the same approach or have the same target. To improve efficiency, similar strategies should be identified and merged.

C. Related work

John N. Warfield developed the ISM approach, which generates a hierarchical structure to analyze relationships between elements in complex systems [7]. The hierarchical structure visualizes the construction of the whole system based on the dependence between elements. Elements influencing other elements are placed in a lower layer. On the other hand, elements depending on other elements are placed in a higher layer. The dependency of elements is expressed in a relation matrix where the rows and columns are the elements. We expect ISM to assist a GQM+Strategies grid reviewer (e.g. business analyst) in understanding and analyzing models.

Conflict management is field of research to handle and resolve conflicts. T. Ruble and K. Thomas [9] identified five conflict handling modes: competing, avoiding, accommodating,

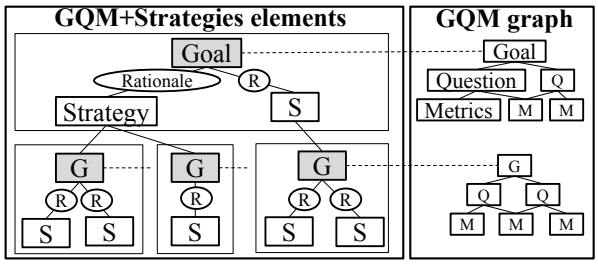

Fig. 1. GQM+Strategies grid

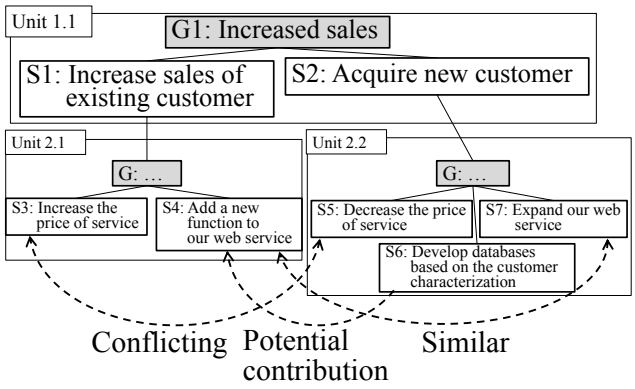

Fig. 2. Example of a GQM+Strategies grid with horizontal relations

collaborating, and compromising. These modes are classified based on whether the opposing persons are assertive or cooperative. We expect the theory of conflict management to be applicable to conflicting strategies, similar strategies, and potential contributions.

Several researchers have struggled to improve business process models. M. E. Khalaj et al. suggested a semantic framework to model business process based on software architectural concepts, which significantly reduces the misunderstanding of complexities [10]. W. Khlif supposed that combining the semantic aspect with the structural aspect further reduces the control flow complexity of a business process modeled in the Business Process Modelling Notation [11].

The GQM+Strategies method has been expanded. T. Kobori et al. suggested the Context-Assumption-Matrix (CAM), which refines the GQM+Strategies model by extracting rationales based on analyzing the relationships between stakeholders [12][13]. C. Shimura defined modeling rules for GQM+Strategies with a metamodel and design principles that consist of relationship constraints between GQM+Strategies elements [14]. This method helps identify and improve potential problems and strategic risks. To develop a strategy that considers the requirements of both the user and the business, C. Uchida et al. described the GO-MUC method (Goal-oriented Measurement for Usability and Conflict) [15].

III. HORIZONTAL RELATION IDENTIFICATION METHOD (HORIM)

Previously we proposed HoRIM [6] to identify and handle horizontal relations of strategies in GQM+Strategies grids. Fig. 3 overviews HoRIM. After constructing a GQM+Strategies grid, HoRIM is used as a review. HoRIM consists of the

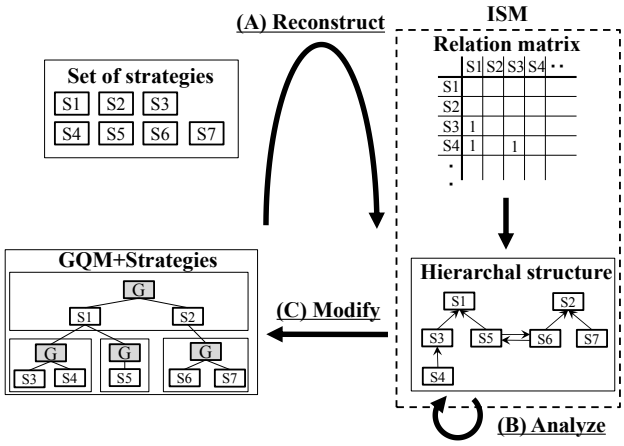

Fig. 3. Overview of HoRIM

following steps: reconstruction, analysis, and modification. In the reconstruction phase, the hierarchical structure involving horizontal relations is generated by ISM. In the analysis phase, HoRIM detects the differences between an initial GQM+Strategies grid and the hierarchical structure. Then the identified horizontal relations are classified into three categories: conflicting strategies, similar strategies, and potential contributions. In the modification step, several alternatives to deal with horizontal relations based on the five-modification approach are suggested and examined. Finally, the GQM+Strategies grid is improved according to the alternatives. This process is iteratively executed to address horizontal relations and improve the GQM+Strategies grid.

A. Reconstruct

In this step, the hierarchical structure consisting of the strategies is generated by ISM. ISM uses a relation matrix to determine the dependency between any two elements. An analyst creates relation matrix $A = \{a_{ij} \mid i, j=1, 2, \cdots, n\}$ to express all direct binary relationships. "n" means the number of the strategies, which are the rows and columns of the relation matrix. If the column element depends on the row element, a value of 1 is inputted. Otherwise, 0 is inputted. The analyst specifies all relations (involving horizontal relations) between strategies into the relation matrix. Then the hierarchical structure is automatically generated by the algorithm as ISM.

B. Analyze

In this step, horizontal relations are identified by the hierarchical structure. ISM generates the hierarchical structure from all dependencies between the strategies whereas the GQM+Strategies grid is constructed based on top-down approach. Therefore, the hierarchical structure of ISM expresses the relations that the GQM+Strategies grid cannot specify. To identify horizontal relations, HoRIM detects the difference between the initial GQM+Strategies grid and the hierarchical structure by ISM.

C. Modify

Finally, the GQM+Strategies grids are modified from the viewpoint of horizontal relations. HoRIM employs the five modification approach: detail, select, integrate, breakthrough, and relate.

Detail means that applying strategies concretely prevents the overlap of strategic objects. This is particularly effective when strategies are described abstractly. Select means to compare two or more strategies before choosing one. Select is effective when the strategic priorities differ significantly. Integrate means to combine two strategies into one unified strategy. An integrated strategy often becomes an abstract version of the original ones. Breakthrough means to create new strategies to resolve conflicting strategies. Techniques such as a conflict resolution diagram [16] can be utilized to discover a new strategy. Relate means that the relation between the strategies with horizontal relations is added.

When several modification alternatives are considered, they are examined based on the following viewpoints: certainty of solving the problem, contribution toward goals, potential negative effect, and obstacles for execution. From the viewpoint of certainty, the analyst answers how the modification alternative resolves the problem (e.g., non-efficiency by conflicting strategies or dispersion of business process by similar strategies.) From the viewpoint of the contribution to goals, the analyst should confirm that the alternative does not interrupt the original goals in GQM+Strategies grid. A potential negative effect means the alternative adversely influences other strategies. Alternatives with negative effects may induce other horizontal relations. An execution obstacle indicates a difficulty or complexity of re-organization or the new strategy that the alternative specifies.

IV. EVALUATION

A. Experiment planning

We compared the effectiveness of identifying and modifying horizontal relations by HoRIM and an ad hoc review, which is subjectively executed. During our evaluation, we investigated the research questions described in section I. To answer the research questions, we conducted two experiments on GQM+Strategies grids. One reviewed the grid, while the other modified it. Table I overviews our experiments.

The review experiment involved six university students majoring in computer sciences. All students were familiar with how to model GQM+Strategies grids. The students were divided in two groups of three students (Groups A and B). Each subject completed two exercises, where he or she identified the horizontal relations from the GQM+Strategies grid with HoRIM or ad hoc review. To reduce the learning effects, Group A completed exercise 1 by HoRIM, while Group B executed exercise 1 by an ad hoc review. In exercise 2, the methods were reversed for each group. Both GQM+Strategies grids included 3 level layers and had 23 strategies. We measured the number of identified horizontal relations in this experiment.

The modification experiment involved university students majoring in computer sciences. The 12 subjects were divided randomly into two groups of six (Groups A and B). Group A performed exercise 3 by HoRIM, while Group B executed

exercise 3 by an ad hoc method. In exercise 4, the methods were reversed.

The materials of the grid already specified three horizontal relations: conflicting strategies, similar strategies, and potential contribution. Firstly, the subjects suggested all modification alternatives that they could envision. Then they modified and improved the GQM+Strategies grid to deal with horizontal relations. The grids in this experiment differed from the ones in the review experiments. The material grids were constructed based on two industrial cases. The grids were simple as they included two level layers and seven strategies. We measured the number of modification alternatives.

Four researchers, who studied the GQM+Strategies framework or the business models, evaluated the validity of the modified grids. They ranked the modified grids because it is difficult to estimate the absolute validity. The evaluators could not give the same rank to different objects.

B. Results

Fig. 4 shows the results of the review experiment. The precision and recall were calculated from the identified horizontal relations and the correctly defined horizontal relations. Table II shows the results of the modification experiment of the GQM+Strategies grids and the evaluation of the modified grids. Num. stands for the number of modification alternatives and the evaluator rows show the rank of the modified grids. Attr. stands for the integration value of the evaluation by Thurstone's method [17][18], which converts an ordinal scale into an interval scale, assuming that the quality of the samples follows a normal distribution. A high figure means a high quality modified grid, while a low figure means the low quality. Fig. 5 shows the boxplots diagram of the number of suggested alternatives and the result of Thurstone's method. Table III shows Kendall's coefficient of concordance [19] and the results of Mann-Whitney's U test.

C. Discussion

1) RQ1

The average recall of HoRIM is about 1.48 times that of the ad hoc review (Table II), confirming that HoRIM is more effective. Subjects using HoRIM suggested relations involving three or more strategies, whereas the ad hoc review identified relations between two strategies. These findings indicate that HoRIM helps understand more complex strategies, confirming that it assists in analyzing complex GQM+Strategies grids.

The precision of HoRIM is lower than that of the ad hoc review for the cosmetic company in exercise 1. In addition, the group using the ad hoc review in exercise 1 made more mistakes in exercise 2 using HoRIM. These results imply that not all horizontal relations suggested by HoRIM are correct. However, the significant difference is not observed (Table III).

2) RQ2

In exercise 3, we confirmed that HoRIM is effective as the subjects with HoRIM suggested more modification alternatives and higher quality modified grid. On the other hand, in exercise 4, we found no significant difference between the number of alternatives. In addition, the rank of the modified grid indicates no concordance between the evaluators (Table II and Table III). It is considered that the subjects using ad hoc in exercise 4 had already learned HoRIM in exercise 3. In fact, we confirmed concept words of HoRIM (e.g., detail or select) in the answers of the group that did not use HoRIM in exercise 4. Individual differences seem to be low as significant differences are not found in exercise 4 despite finding significant differences in exercise 3. The effectiveness of HoRIM does not seem to depend on the complexity or size of the GQM+Strategies grid as we designed the grids to have the same size, complexity, and types of horizontal relations. In conclusion, HoRIM appears to effectively modify GQM+Strategies grids.

The subjects using HoRIM suggested modification alternatives from various viewpoints. Subjects without HoRIM tended to delete one of the conflicting strategies (i.e., select),

TABLE I. OVERVIEW OF OUR EXMERIMENTS

					Method	
	Purpose	***Task***	***Target***	***Time***	***Group A***	***Group B***
Ex. 1	To evaluate the effectiveness of identifying horizontal relations	Identify horizontal relations from the GQM+Strategies grid	6 students	Individual	HoRIM	Ad hoc
Ex. 2	To evaluate the effectiveness of identifying horizontal relations	Identify horizontal relations from the GQM+Strategies grid	6 students	Individual	Ad hoc	HoRIM
Ex. 3	To evaluate the effectiveness of modifying horizontal relations	Improve the GQM+Strategies grid	12 students	50 min	HoRIM	Ad hoc
Ex. 4	To evaluate the effectiveness of modifying horizontal relations	Improve the GQM+Strategies grid	12 students	50 min	Ad hoc	HoRIM

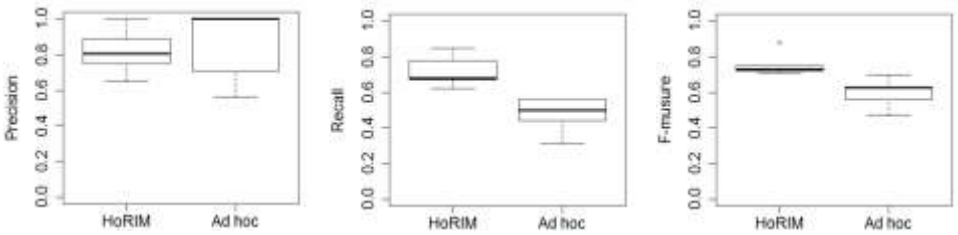

Fig. 4. Boxplots of the experiment reviewing GQM+Strategies grid

TABLE III. RESULTS OF THE EXPERIMENT MODIFYING GQM+STRATEGIES GRIDS

		Subjects											
		1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***
Ex. 3	Method	HoRIM						Ad hoc					
	Num.	4	10	8	6	6	7	5	6	3	4	2	4
	Evaluator 1	10	5	4	12	1	3	2	6	8	9	11	7
	Evaluator 2	12	1	5	6	2	7	4	3	8	10	11	9
	Evaluator 3	2	3	5	4	8	1	9	7	10	11	12	6
	Evaluator 4	1	4	9	3	7	2	10	8	6	11	12	5
	Attr.	**0.65**	**0.98**	**0.68**	**0.59**	**0.88**	**1.00**	**0.65**	**0.67**	**0.47**	**0.23**	**0.00**	**0.59**
Ex. 4	Method	Ad hoc						HoRIM					
	Num.	2	4	5	4	5	4	7	6	7	1	3	3
	Evaluator 1	9	10	2	8	7	12	1	3	5	6	11	4
	Evaluator 2	3	2	11	6	10	5	4	7	8	9	12	1
	Evaluator 3	12	4	11	1	3	10	5	2	7	8	6	9
	Evaluator 4	2	3	5	1	4	7	6	10	12	11	9	8
	Attr.	**0.46**	**0.76**	**0.38**	**1.00**	**0.57**	**0.15**	**0.92**	**0.67**	**0.23**	**0.22**	**0.00**	**0.72**

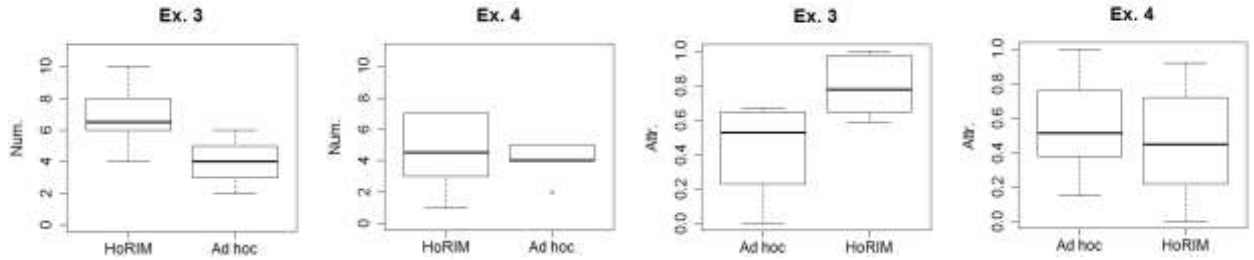

Fig. 5. Boxplots of the experiment modifying GQM+Strategies grids

TABLE II. RESULTS OF THE TEST

		Kendal	**Wilcox**
Ex. 1 & 2	Precision	-	0.423
	Recall	-	0.004
	F-measure	-	0.004
Ex. 3	Num.	-	0.030
	Rank	0.035	0.030
Ex. 4	Num.	-	0.762
	Rank	0.396	0.699

while subjects with HoRIM tried to coordinate the strategies (i.e., detail or breakthrough). In exercise 3, the GQM+Strategies grid contained conflicting strategies; S1 specifies the increment of competition participants, while S2 specifies setting the competition theme. This conflict is based on the assumption that only people interested in the theme participate the competition. Subject 11 without HoRIM deleted S2 upon considering the impact to its goal. On the other hand, subject 5 with HoRIM modified S2 into a detailed strategy specifying that participants could choose between several themes. Similarly, subject 11 with HoRIM suggested detailed strategies in exercise 4.

The evaluation of several modified grids depended on the evaluators. In particular, the grids modified by a detailed approach tended to receive dispersed evaluations. In exercise 3, the grids had similar strategies. S3 and S4 specify the increment of feedback to the participants. Subject 1, who received dispersed evaluations, suggested detailed strategies; one specified that proper feedback is increased, while another specified that participants receive feedback quickly. One evaluator judged that the two strategies represented two viewpoints (quality and delivery), whereas another evaluator felt that they were the same as both improved feedback.

How the modified grids are assessed is one cause of the difference in the evaluation. One evaluator used the potential of the modified grid to determine the validity. Another evaluator assessed the grids based on his or her perception of what the correct grid should be. The latter approach will result in poor marks if the grid is inconsistent with the evaluator's expectations regardless of the grid quality. In our experiment, it is presumed that we introduced the background and premise of

the GQM+Strategies grid's domain to the evaluators and subjects relatively well in exercise 3, but not in exercise 4, leading to a misunderstanding in exercise 4.

D. Findings and their usage

Our experiments revealed the following three findings:

- The review experiment demonstrated that a structural analysis method such as ISM can effectively identify misalignments in the strategy models. Therefore, the business analyst should utilize HoRIM or a structural analysis method when analyzing complex and large strategy models.
- Exercise 3 confirmed that the concept of the modification for horizontal relations leads to more modification alternatives and the proper improvement of the strategy models. Therefore, the business analyst should consider the modification approach and the evaluation viewpoints in HoRIM when improving the strategy models.
- Exercise 3 and 4 indicated that the evaluation of strategy models depends on the background and promise of the domain. Therefore, the researchers should devise a method to reconcile the background and promises of the amenders and the evaluators when validating strategy models.

E. Threats to validity

One threat to internal validity is the difference between the abilities and experiences of the subjects. However, this bias was removed by dividing the subjects into two random groups. For exercise 1 and 3, Group A employed HoRIM, while group B used an ad hoc review. The employed methods were reversed in exercise 2 and 4. Exercises 1, 2, and 3 demonstrate that HoRIM is more effective than an ad hoc review. However, the small sample size cannot confirm the precision or effectiveness of HoRIM. In the future, an experiment involving a larger sample size is necessary.

There are two threats to external validity. First, the subjects were students with limited knowledge of the strategies in the GQM+Strategies grids. Second, only two GQM+Strategies grids were examined in each experiment. The small number of strategies may decrease Ho-RIM's superiority because simple GQM+Strategies grids are easily analyzed.

V. Conclusion and Future Work

GQM+Strategies grids frequently contain relations between the strategies in different branches. Such relations are defined as horizontal relations. To handle horizontal relations, we proposed the Horizontal Relation Identification Method (HoRIM) to detect the difference between the initial GQM+Strategies grid and a model by ISM. HoRIM provides a framework to improve grids. Our experiment demonstrates that HoRIM improves the effectiveness of not only identifying horizontal relations but also modifying GQM+Strategies grids.

In the future, we plan to replicate our experiment modifying the GQM+Strategies grids to consider the learning effects. Additionally, we plan to expand HoRIM so that it can distinguish the types of relations (e.g., positive, negative, and overlap), which should improve the analysis of hierarchical structures.

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