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ABSTRACT
This paper provides a solution to discourse structure adaptation in the process of automatic hypermedia presentation generation. Existing approaches to discourse structure composition are based on the assumption that a user can comprehend relations between the elements in a discourse structure if the overall structure is semantically coherent. This assumption does not, so far, take into account specific user needs. In this paper we show that although discourse structure composition approaches significantly differ, a general model of the composition process can be derived. Within this general model we identify how adaptation can be applied. We formulate the problem of discourse adaptation with regard to the general model and present our proposed solution. We implement this solution within the process of composing discourse structures for newspaper articles.

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Combining Coherence and Adaptation in Discourse-oriented Hypermedia Generation

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Abstract. This paper provides a solution to discourse structure adaptation in the process of automatic hypermedia presentation generation. Existing approaches to discourse structure composition are based on the assumption that a user can comprehend relations between the elements in a discourse structure if the overall structure is semantically coherent. This assumption does not, so far, take into account specific user needs. In this paper we show that although discourse structure composition approaches significantly differ, a general model of the composition process can be derived. Within this general model we identify how adaptation can be applied. We formulate the problem of discourse adaptation with regard to the general model and present our proposed solution. We implement this solution within the process of composing discourse structures for newspaper articles.

1 Introduction

Semantic frameworks used by automatic hypermedia presentation generation systems contain domain ontologies and large amounts of annotated media items assembled from heterogeneous sources that are not user- or task-tailored. One of the main goals in the semantic-based hypermedia presentation generation research is to provide a higher-level conceptual structures that ensure coherent organization of media assets for a particular presentation in the context of a dynamic heterogeneous environment [7, 8, 10]. This goal is achieved by creating discourse structures. A discourse structure represents the conceptual organization of a presentation. It is composed according to particular genre characteristics and consists of ordered groups of domain concepts. The notion of genre is used to ensure coherence.

A genre represents established communication patterns that help readers or viewers to recognize and interpret information more efficiently [5]. Existing genre theories [4, 9] and narrative principles [1] motivate the semantic organization of concepts in a discourse structure. It is assumed that a user can comprehend relations between the elements if the overall discourse structure is semantically coherent. This assumption does

not, so far, take into account specific user needs. Therefore, resulting discourse structures are not user tailored. For example, users with different knowledge in the domain might have different views on what organization of concepts in the discourse structure is more coherent. For a novice user it is easier to see semantic relations between the concepts if these concepts are closely related. In contrast, an expert user has understanding of much broader areas in the domain knowledge space and is thus able to relate concepts from different distant subareas.

Techniques used by the adaptive hypermedia community, such as adaptive content selection, adaptive linking and adaptive presentation specifically address the problem of providing a user with coherent sets of relevant media items [2, 3, 11]. Repositories used by adaptive hypermedia systems usually contain media items that can meet the requirements of particular user tasks and user characteristics. Thus, it is possible to provide media material that is selected and composed to address specific user needs. The different nature of underlying data makes it difficult for hypermedia presentation generation systems to apply techniques developed by adaptive hypermedia research.

To address the problem of making presentations produced by hypermedia presentation generation systems more suitable to specific user needs, we aim at creating a flexible adaptation layer that can handle a dynamic discourse composition process and that is independent of this process. Our goal is to provide discourse structure adaptation that, on the one hand, preserves coherence of resulting discourse structures and, on the other hand, makes them more appropriate to users with different levels of domain knowledge.

The outline of the paper is as follows. Section 2 presents related work in the area of hypermedia presentation generation. We pay particular attention to the steps taken in creating discourse structures. In Section 3, we derive a general model of the discourse structure composition process. Based on this model we formulate the problem of discourse adaptation. Section 4 presents our proposed solution to the discourse adaptation problem and illustrates it with examples. These examples are the results of applying our proposed solution to the process of composing discourse structures for newspaper articles used within the Samp*L*e system [6, 7]. We conclude in Section 5 with an evaluation of our approach and directions for future work.

2 Hypermedia Presentation Generation Systems

In this section we describe related work in the area of semantic-based hypermedia presentation generation. We pursue the goal of identifying a general model of the discourse composition process. Thus, we highlight similarities between the systems in the steps they follow to compose discourse structures.

As mentioned in the previous section, a discourse structure contains domain concepts that are grouped and ordered to ensure coherence. Domain concepts and relations between them plus media items annotated with these concepts form the semantic framework. The selection of domain concepts for the discourse structure is done based on (1) relevance of each element in the discourse structure with regard to the complete discourse structure belonging to a certain genre (*global coherence*) and (2) the coherence relationships between a concept and other concepts in the discourse structure (*local co-*

herence). As a result, concepts are ordered in such a way that the semantic relationships between the concepts in a discourse structure become apparent.

In the **Artequakt project** [10] a human author creates templates for biographies of artists. A template consists of queries to the knowledge base. Each query retrieves data about one aspect of an artist's life. The author determines global coherence by selecting domain concepts for queries. S/he specifies local coherence by grouping and ordering queries using constructs that specify the preferred order of query appearances within the template. The *Context* construct allows for a certain level of adaptivity by identifying specific parts of a template available only to users with a necessary level of domain knowledge.

In **DISC** [8], discourse structures are represented by dynamic rule-based templates. A template specifies the main character and the genre and is divided into narrative units, e.g. a narrative unit about the professional life of a person. A narrative unit contains discourse rules that define which domain concepts can play a role of related characters in the discourse structure. For example, for a main character "Rembrandt", "Lastman" can play a role of the related character "teacher". Hence, narrative units determine global coherence of concepts for a discourse structure. In addition, discourse rules specify local coherence by defining what data about the related character can be presented. A dynamic template produces different discourse structures depending on what related characters can be found in the knowledge base.

Samp*L*e [6] uses discourse flow templates as an initial representation of a discourse flow for the genre. A discourse template is an analytical framework for building discourse structures for a particular genre. For example, a newspaper article discourse template consists of the components: *Main Event, Context, History, Comments* [12]. Samp*L*e uses rules to specify the mapping between a discourse template and the semantic framework. These rules help to find domain concepts appropriate for each discourse template element. To create a coherent discourse structure retrieved domain concepts are differentiated using coherence rules. Coherence rules take into account a part of the discourse structure which is already composed and a set of concepts that are appropriate for inclusion at the next step.

3 Problem of Discourse Adaptation

The descriptions in the previous section show that existing hypermedia presentation generation approaches create discourse structures following similar steps. They specify a *discourse flow* for a particular genre with human-authored templates (Artequakt), rule-based templates (DISC) or discourse templates (Samp*L*e). Then *global coherence* determines the *relevance of concepts* for a discourse structure based on genre characteristics (e.g. data about parents of a main character is relevant for inclusion in a biography). To compose a final discourse structure, relevant concepts are distinguished based on *local coherence* principles such as ordering preferences (Artequakt), roles of these domain concepts (DISC) or appropriateness of the concepts with regard to explicit semantic coherence rules (Samp*L*e). The result of this process forms sets of *selected domain concepts* for each section of the discourse structure. These steps can be combined into a common model presented in Figure 1.

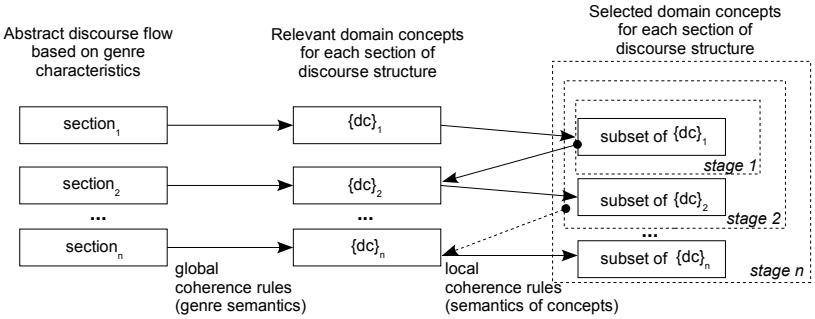

Fig. 1. A general model of the discourse structure composition process

The coherence achieved by hypermedia presentation generation approaches can be regarded as "general" coherence, since specific user features are not taken into account. We argue that discourse structures can be tailored to different users if we adapt decisions taken while evaluating local coherence to specific user needs.

Decisions about global coherence are guided by the notion of genre which represents established communication patterns [5] and is thus applicable among various user groups. On the other hand, decision about local coherence are guided by narrative principles. The discourse composition process semantically links domain concepts to achieve coherence. For different users the view on semantic relations between the concepts can vary. A user with little domain knowledge might be unfamiliar with one or more concepts in the discourse structure. The semantic relation between the two unfamiliar concepts will be unclear to the user and she might have difficulties in understanding why one concept follows another in the discourse. Thus, users with different domain knowledge have different views on the coherence relations between elements so the notion of local coherence can vary. Hypermedia presentation generation approaches do not take this aspect into account.

Thus, adding adaptation to a discourse structure composition process results in *the problem of enabling modifications in evaluating local coherence between the concepts while preserving global coherence of the obtained discourse structure*. This problem can be addressed if we are able to recognize:

(A) what user characteristics we want to adapt to;
(B) what user needs of each type are;
(C) how the application of local coherence rules in the discourse structure composition process can be adapted according to the identified user needs.

After identifying a general model of the discourse composition process and formulating the discourse adaptation problem in terms of this model, we present our solution to the problem according to these three points.

4 Proposed Solution to Discourse Adaptation

This section presents a general description of the solution for discourse adaptation in automated generation of multimedia presentations. In order to evaluate this solution and to provide concrete examples, we implement this solution within the the Samp*L*e system [6, 7]. We choose Samp*L*e as testing platform since it contains explicitly encoded local coherence rules, as described in Section 2. Explicit coherence rules provide the freedom in applying our approach to the necessary step in the discourse structure composition process, without having to modify other components. The examples are based on the process of creating a discourse structure for the presentation about a Dutch painter Piet Mondrian in the newspaper article genre.

Samp*L*e creates discourse structures by specifying a mapping between a discourse flow template for the genre (e.g. the discourse flow for the newspaper article genre: *Main Event, Context, History, Comments*) and a semantic framework. This mapping finds sets of relevant domain concepts for each section of the discourse flow (global coherence). Samp*L*e selects out of these sets appropriate domain concepts that form a coherent discourse structure. Concepts are selected based on coherence rules that verify coherence of each concept with regard to the other concepts in the discourse structure (local coherence).

(A) To demonstrate our proposed solution to the first point of the problem description in Section 3, we chose two representative types of users - novice and expert. We aim to provide adaptation of the discourse structure composition process according to the knowledge level of users of each type.

(B) Depending on the user types we describe a number of user needs as the basis for the ongoing argument. Novice users have very little knowledge about the domain at hand. Thus, discourse structures for such users should be created taking into account relevant semantic relations between the concepts. Intense presentations often contain large semantic gaps between the concepts. A novice user not very familiar with the concepts might find such presentation incoherent. This situation might occur either in a situation when the presentation concentrates on one subject area or on scattered subject categories. For the latter case the semantic gap between the concepts will be even larger leading to inconsistent presentation.

An expert, however, might be interested in an extensive presentation comparing concepts from different subject categories. An expert sees the semantic connection between the concepts more easily and does not require repetitions or detailed explanations.

(C) To realize such modifications in the discourse structure composition process behavior we have to specify (1) which coherence rules are influenced and (2) how these rules are influenced by specific user needs. Then we need (3) to identify the mapping between the desired adaptation of the coherence rules and the coherence rules currently used in the discourse structure composition process. To provide such a mapping both adaptation rules and coherence rules need to have common constructs in terms of which they can communicate. Having the mapping we can encode the adaptation rules. After that we have (4) to find a particular realization of this mapping in the discourse composition process.

We explain each of the four steps in more detail below. Points (1) and (2) are case-specific and thus no common description can be provided here. We demonstrate these

points using examples from the discourse composition process used in Samp*L*e. Points (3) and (4) first present our proposed solution in the general case and then illustrate it with examples.

(1) Coherence rules influenced by adaptation

Example: In the process of composing discourse structures for the newspaper article genre the following local coherence rules can be affected by adaptation [6]:

- *Repetition*: repetition of concepts within a discourse structure is not allowed;
- *Consistency*: each following concept being added to a discourse structure has to have a semantic relation to the concept added at the previous step;
- *Pace*: all the concepts being added to a discourse structure should be within the scope of the main subject;
- *Succession*: do not include more specific concepts in a discourse structure if more general concepts related to them have not been introduced.

(2) Modifications of coherence rules according to the user types

Example: Each of these rules can be modified to be more suitable for a particular user.

- The *Repetition* rule is appropriate as it is for an expert while for a novice user the opposite holds. It might be useful to repeat some concepts for a novice user to ensure better understanding of the material.
- The *Consistency* rule might be applied to both expert and novice cases. The semantic relation between the concepts means that two concepts are explicitly connected via a semantic relation in the semantic framework. This does not contradict the situation where concepts are still related but there is no explicit relation in the framework that connects them. Then we can choose to apply it for a novice but to relax it for an expert.
- The *Pace* rule is a typical example of a rule that should be applied to novice but not to expert.
- The *Succession* rule might be context dependent. Depending on the particular case we might have to apply it also for an expert to support consistency.

(3) Mapping via common constructs

A set of common constructs consists of concepts used by both types of rules: discourse structure composition rules and adaptation rules. In the discourse structure composition process we need to identify constructs that are used in the local coherence rules. We then create adaptation rules that describe in terms of these constructs how evaluation of the local coherence is influenced by a user type.

Looking at the general process of discourse structure composition presented in Figure 1 we can see that main constructs involved into decisions about local coherence are:

- domain concepts that are already selected to represent the elements of the discourse structure - *current structure*;
- domain concepts that are appropriate to appear inside a certain element of the discourse structure based on global coherence - *relevant concepts*;

– one or more domain concepts that are selected to represent an element of the discourse structure - *selected concepts*.

Outcomes of coherence rules are based on evaluating *current structure* and *relevant concepts* and coming up with *selected concepts* to be added to the *current structure*. Besides, we need the *user type* construct to identify a user type for which the specific rule holds. Thus, these constructs can be used as the basic common constructs specifying the inputs *user type, current structure, relevant concepts* and the output *selected concepts* of the discourse composition rules and adaptation rules.

Example: The figure below represents a particular stage in the process of creating a discourse structure for the article about Piet Mondrian with examples of the local coherence rules. As the result of coherence evaluation both relevant concepts (a principle of using 'Diagonals' and an artist 'van Doesburg') could be included into *SelectedConcepts* set according to the *Repetition* rule, but only 'van Doesburg' was included after applying the *Consistency* rule.

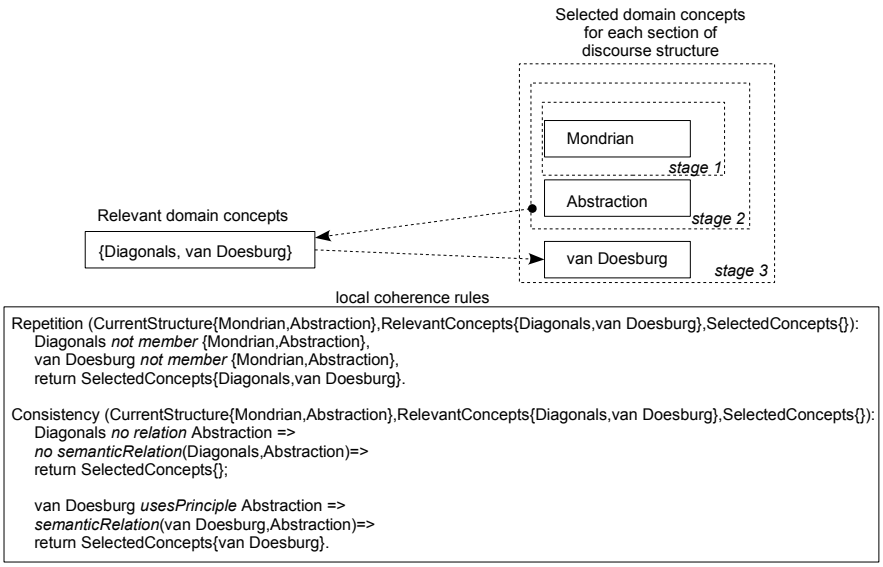

Fig. 2. A stage of the discourse structure composition process

As the next step, we need to create adaptation rules that affect evaluation of local coherence. Adaptation rules have to be specified on the necessary level of abstraction. This means that they have to describe how the evaluation of local coherence changes without referring to the particular means of evaluation on the level of domain concepts. Evaluation on domain concept level is a part of the discourse structure composition process which should be independent from the way adaptation is done in order to be

reusable. This is achieved by using the same datatypes for common constructs in both types of rules. The common constructs in the adaptation rules are initially not instantiated.

(4) Realization of the mapping

Coherence rules and adaptation rules share the basic constructs. Besides, corresponding coherence and adaptation rules refer to the same concept semantics but with different evaluation and thus with different outcome. Therefore, we are able to integrate adaptation rules in the discourse structure composition process in a modular way. The only modification required in the discourse composition process is to identify which coherence rules can be affected by adaptation rules. This is done by introducing a *user type* parameter into the discourse composition rules and instantiating this parameter with the 'standard' user type by default. If the user type is known to the actual composition process then corresponding adaptation rule is applied within this process.

Example: Figure 3 presents the implementation result of applying adaptation rules within the discourse structure composition process in Samp*L*e. The screenshot[1] shows three discourse structures: the first one is created using 'standard' discourse composition process in Samp*L*e and the other two are created using adaptation rules applicable to 'novice' and 'expert'.

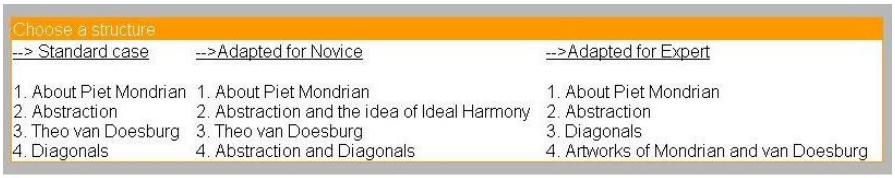

Fig. 3. Examples of discourse structures for 'standard case', 'novice', and 'expert'.

In the case of a novice user, adaptation of local coherence resulted in repeating the concept of 'Abstraction' in the last section of the structure in order to make its comparison with 'Diagonals' easier for the user. For an expert, it is possible to present more details in the presentation such as to provide a comparison of artworks belonging to two artists.

5 Evaluation and Conclusions

This paper explores an approach to add adaptivity into the discourse structure composition process used by automatic hypermedia presentation generation systems. To date, existing hypermedia presentation generation systems incorporate features that allow users to specify their preferences about a particular type of the presentation (a presentation genre), a specific topic and a presentation format (e.g. HTML or SMIL). In this

[1] http://homepages.cwi.nl/∼media/projects/CHIME/demos.html

paper we address the problem of adapting the content composition process to users with different levels of knowledge in the domain.

Hypermedia presentation generation systems create discourse structures to ensure coherent content composition. They base the evaluation of coherence on existing genre theories and narrative principles, not taking into account specific user needs. We argue that users with different knowledge levels have different views on the coherence relationships between the concepts in a discourse structure. Given this, we provided a general model of the discourse composition process used by existing hypermedia presentation generation systems. We identified how adaptation can be applied within this process. We proposed a solution to the adaptation problem that allows to integrate an independent module with coherence adaptation rules into the discourse composition process.

In order to evaluate our proposed solution, we implemented it within the Samp*Le* system. We tested the solution on the use case of composing discourse structures for the newspaper article genre. The main direction of our current work is to use a larger number of use cases with various local coherence rules and discourse structures belonging to different genres.

We view the content composition process from the content structuring perspective, that is: what higher-level structures can support coherent organization of presented material in the context of a dynamic heterogeneous environment. Another component of this process is content selection supported by adaptive hypermedia techniques which allow to specify whether certain characteristics of content (e.g. complexity or media modality) are appropriate for the particular type of users. We plan to combine the two components in the next prototype. Such combination will enable to produce final presentations where the overall structure and the content of media items is adapted to user needs. It will allow to conduct user tests and to include necessary modifications based on a user feed-back.

An interesting evolution of our work is to extend the approach to adapt not only to a user but also to an author of the presentation. There might be a situation where one person requests a presentation about the particular topic (e.g. a teacher) and another person or a group of people will be the actual viewers of this presentation (e.g. pupils). In this case we might consider matching the aim of the author (e.g. to teach) with the needs of the audience (e.g. specific requirements for coherence relations based on the knowledge level). Adapting coherence rules to both author and user features might cause conflicts in the application of rules. For example, an author might want to create an educative presentation in which s/he repeats some concepts for clarity. The specific audience, however, may consider such presentation uninteresting. We aim to explore possible conflict resolution strategies and integrate them into the adaptation process.

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References

1. D. Bordwell. *Making Meaning - Inference and Rhetoric in the Interpretation of Cinema.* Harvard University Press, Cambridge, Massachusetts, 1989.
2. P. Brusilovsky. *User Modeling and User-Adapted Interaction 11*, chapter Adaptive Hypermedia, pages 87–110. Kluwer Academic Publishers, The Netherlands, 2001.
3. P. Brusilovsky. Developing Adaptive Educational Hypermedia Systems: from Design Models to Authoring Tools. *Authoring Tools for Advanced Technology Learning Environments*, pages 377–409, 2003.
4. D. Duff. *Modern Genre Theory*. Pearson Education Limited, Edinburgh Gate, United Kingdom, 2000.
5. T. Erickson. Rhyme and Punishment: The Creation and Enforcement of Conventions in an On-Line Participatory Limerick Genre. In *Proceedings of the 32rd Hawaii International Conference on System Science*. IEEE Computer Society, January 5-8, 1999.
6. K. Falkovych and F. Nack. Composing Discourse based on Genre Semantics. Technical Report INS-E0502, CWI, December 2005.
7. K. Falkovych and F. Nack. Context Aware Guidance for Multimedia Authoring: Harmonizing Domain and Discourse Knowledge. *Multimedia Systems Journal, Special issue on Multimedia System Technologies for Educational Tools, S. Acton, F. Kishino, R. Nakatsu, M. Rauterberg & J. Tang eds.*, 2006.
8. J. Geurts, S. Bocconi, J. van Ossenbruggen, and L. Hardman. Towards Ontology-driven Discourse: From Semantic Graphs to Multimedia Presentations. In *Second International Semantic Web Conference (ISWC2003)*, pages 597–612, Sanibel Island, Florida, USA, October 20-23, 2003.
9. A. Huxley. *Collected Essays*. Harper, New York, 1959.
10. S. Kim, H. Alani, W. Hall, P. Lewis, D. Millard, N. Shadbolt, and M. Weal. Artequakt: Generating Tailored Biographies with Automatically Annotated Fragments from the Web. Presented at the Semantic Authoring, Annotation and Knowledge Markup (SAAKM) 2002 Workshop at the 15th European Conference on Artificial Intelligence (ECAI 2002), Lyon, France.
11. A. Kobsa, J. Koenemann, and W. Pohl. Personalised hypermedia presentation techniques for improving online customer relationship. *The Knowledge Engineering Review*, Vol. 16(2):111–115, 2001.
12. T. A. van Dijk. *Handbook of Qualitative Methods in Mass Communication Research*, chapter The interdisciplinary study of news as discourse, pages 108–120. Routledge, London, 1991.