Collaborative Hypermedia Education with the VIENA Classroom System

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Abstract

VIENA Classroom is a collaborative hypermedia education system which is a component of the Virtual Interactive Environment for Workgroups (VIEW), a collaborative environment based on distributed object-oriented database technology. An important feature of the system is its user-friendly question support facility. By means of a multimodal natural language interface the students can formulate their questions directly in Japanese which are either answered by accessing a FAQ knowledge base or collected and transferred to the teacher for later processing. As additional valuable assistance for the students we provide the possibility to browse through automatically generated FAQ lists.

1 Introduction

The last years have witnessed a rapidly growing interest in “learner-centered” approaches to education which aim at replacing passive lecture attendance and textbook reading by active exploration and construction [14]. This recent renaissance of well-established problem-based learning strategies (“learning by doing”, “training on the job” etc.) is due to now available advanced computer technologies. Hypermedia and collaborative environments are two compelling technologies that make it possible to engage the students in the solution of interesting tasks which leads to active participation and high motivation.

VIENA Classroom (short for VIEW NAtural Classroom) is a collaborative hypermedia education system that addresses a wide range of applications from intensive on-line teaching in small groups including group discussions and solving problems by team-work to off-line teaching for large communities such as night schools or wide area teaching with time differences. VIENA Classroom is a component of the Virtual Interactive Environment for Workgroups (VIEW), a collaborative environment that utilizes distributed object-oriented database technology. In order to provide the required high flexibility as concerns the personalized display of the shared information, we apply the deputy object model [15] which allows the creation of multiple deputy display objects from a media object by selecting, adding and modifying attributes and methods. Constraints on the personalization can be defined by introducing display environments so that a certain degree of common perception can be enforced.

An important feature of VIENA Classroom is its user-friendly question support facility. We provide the students with a multimodal natural language interface to formulate their questions directly in Japanese. The computed semantic representations are applied to the retrieval of corresponding answers from a FAQ knowledge base or to the collection of semantically equivalent new questions. FAQ frequency data is used for the display of new questions to the teacher, as input for the improvement of the teaching material and for the automatic generation of context-sensitive FAQ lists. The FAQ lists can be browsed through by the students to serve as valuable assistance for the formulation of questions.

The rest of the paper is organized as follows. After a short survey of recent related work we give a brief overview of the VIEW system and the system architecture of VIENA Classroom. Then we deal in more detail with the features of the question support facility. Finally, we present the applied techniques for the natural language interface.

2 Related Work

The recent development of high speed computer networks and the increasing number of multimedia computers are opening up new application domains of computer systems including the area of applications to support cooperative work of people. CSCW (Computer-Supported Cooperative Work) systems are defined as computer-based systems that support groups of people engaged in a common task and that provide an interface to a shared environment [7]. Most of the CSCW systems developed so far are combinations of video systems, communication facilities and basic window sharing mechanisms.

Commercial products such as desktop video conferencing systems (e.g. [2; 21]) have some capability of distance presentation utilizing video phones, white boards, telepointers etc., however, in general without any database support. Database support for collaborative work and management of multimedia data are two major issues in designing multiuser hypermedia systems [9;22] which allow flexible locking and change notification utilizing databases for sharing.

An appropriate data model of time-based media [8] has to include the concept of interpretation of a BLOB (Binary Large OBject), derivation of media objects, and composition of media objects on display. So far, this is still not covered by some existing multimedia models including HyTime [13]. Since traditional database view mechanisms cannot provide a sufficient degree of flexibility for sharing information, new concepts such as proxies [12], MultiView [17] or adapters [19] have been proposed.
Besides many other challenging application domains, CSCW systems possess a high potential of providing the required framework for collaborative education systems. Only recently, research efforts have focused on this new field, examples of first successful prototype systems are CoVis [6], SpeakEasy [11] or CSILE [18].

3 Overview of VIEW

The Virtual Interactive Environment for Workgroups consists of a number of applications which include besides VIENA Classroom also the office system VIEW Office and the conference system VIEW Conf. The basic media services for communications in VIEW are provided by the VIEW Media subsystem. VIEW uses distributed object-oriented database technology extended to have functions of active databases featuring Event-Condition-Action mechanisms specialized for human communications.

Virtual Environments such as VIENA Classroom require high flexibility of personalization. Customization of shared information is needed along the following three dimensions:

- customized hypermedia: the users may want to add personal comments to the presented material
- customized display: the users may want to change fonts, colors, emphasizing styles etc.
- customized navigation: the users may want to revisit previously presented material via links or refer to related material in a separate window

In order to provide a sufficient degree of flexible sharing, we developed the concept of deputy objects which allows to create multiple deputy display objects from a certain media object not only by selecting but also by adding and modifying attributes and methods.

There exists a trade-off between personalization and sharing, i.e. it is sometimes necessary to impose constraints on personalization of hypermedia material in order to guarantee some degree of common perception, e.g. to focus attention on a certain point in the teaching material. Therefore, we introduce display environments which allow to define defaults for display and constraints on personalization [10]. Display environments in VIENA Classroom can include all participating students of a lecture or can be restricted to small seminar groups engaged in the collaborative solution of a common task.

4 System Architecture of VIENA Classroom

All communications within VIENA Classroom can be decomposed in four basic communication modes:

- broadcasting: the teacher broadcasts information to all students
- gathering: information from all students is gathered by the teacher
- interacting: individual interaction of the teacher with a specific student
- processing: a student processes the teaching material locally

Based on these communication modes, the following application modes are designed:

- presentation: the teacher broadcasts the teaching material and explanations to the students, the students process the teaching material and take notes, questions by the students are gathered, answers to relevant questions are broadcast to all students
- discussion: the teacher is interacting with a specific student, the interaction is broadcast to the other students, they process the information, contributions are gathered and sent to the teacher and student in discussion
- observation: exercises or exams are broadcast to the students who process them locally, the responses are gathered and evaluated, results are again broadcast to the students

Besides these three application modes reflecting traditional lecturing methods, also situations can be modeled where a certain student takes the role of the teacher, e.g. as chair in a group discussion or leader of a seminar group.

The physical organization of the system is realized as

![Fig. 1: Application mode of presentation](image-url)
client/server architecture. The teacher and students work on client machines whereas the record of lecture as well as the FAQ database is situated at the server. Figure 1 shows an example of the application mode of presentation, the gathering of questions is discussed in detail in Sect. 5. The blackboard object reads the teaching material as well as the actions of the teacher such as pointing, underlining, displaying additional material etc. and broadcasts them to the students. The record of lecture can be used by the students for later review of the lectures. The application mode of discussion (see Fig. 2) provides a shared window which the teacher as well as the student can use for confirming and explaining details of the discussed topic.

The CSCW functionality of VIENA Classroom is implemented under GroupKit (University of Calgary, [16]), a toolkit based on Tcl/Tk for developing real-time groupware applications. GroupKit provides message and event handling mechanisms as well as widgets that are particular to groupware applications, e.g. shared telepointers or multiuser scrollbars. For the efficient administration of the hypermedia data we use Ode (AT&T Bell Lab, [1]) as powerful object-oriented database system with multimedia support, versioning and triggers.

5 Question Support Facility

In VIENA Classroom students are free to ask questions at any time which are either answered directly from the FAQ knowledge base or transferred to the teacher for later processing. A question is always formulated within a specific context in that the student highlights the corresponding passage in the teaching material. It is the responsibility of the teacher to define a uniform context model during the design process of the teaching material.

Based on this definition a student can easily choose a context of the context model by double-clicking within the concerned area. If a student makes a different selection, e.g. to mark a specific term or phrase, the

![Fig. 2: Application mode of discussion](image)

![Fig. 3: Example of overview of new questions](image)
A frequently asked question has to be resolved according to the context. The same concept is also applied to hot spots in figures or movies.

For each of the contexts new questions are collected and grouped according to their semantic representation. Furthermore, for each group of semantically equivalent questions a representative question is computed by making use of generation templates (see Sect. 6). These representative questions are used to give the teacher an informative overview of the actual situation in the classroom (see Fig. 3 for an example).

The new questions are ranked on the basis of the frequency data so that the teacher can answer the most urgent questions first. As additional information the corresponding context in the teaching material as well as the original questions and names of senders are displayed. An asterisk is used to mark questions with context resolution. If such a question is selected, the corresponding text passage is highlighted in the context window.

According to the personal preferences of the teacher, the question support facility can be configured as filter that collects questions until the next answering period, e.g. for each question, every ten minutes, up to breakpoints in the teaching material, after the lesson, if a question has been asked more than five times etc.

The collected FAQ frequency data can serve as valuable input for the improvement of the teaching material. A quick first solution for the teacher is to simply add relevant questions and answers to the lesson until he/she has more time to develop a new revised version of the material. Answers by the teacher are not restricted to simple text but can also consist of a sequence of animated actions such as pointing, highlighting, presenting additional clarifying hypermedia material etc. The answering can be performed on-line as part of the lecture, e.g. by entering into discussion with the concerned student in a shared window, or off-line after the lecture.

Another important use of FAQ is the automatic generation of context-sensitive ranked FAQ lists which can be browsed through by the students before formulating a new question. This is especially useful for situations where the student does not know how to exactly formulate the question and would like to have some guidance. Figure 4 gives an example, FAQ which are marked with an asterisk have not been answered yet by the teacher, the submission of such a question provides an easy way of increasing its priority of answering.

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Finally, Fig. 5 summarizes the above explanations by displaying the physical organization for the application mode of presentation including the question support facility. The FAQ knowledge base is stored centrally at the server whereas the requests in natural language are processed locally in order to increase overall system efficiency.

6 Natural Language Interface

In spite of the many ambitious attempts of building successful natural language interfaces, they are today still far away from widespread practical use (for a good recent survey see [3]). The reason for this are the many limitations that still exist and that are mainly caused by two factors: missing customization, resulting in unexpected restrictions, and missing integration, responsible for insufficient performance and wrong interpretation.

As concerns missing customization we stress the importance of empirically collecting the training and test set so that realistic input sentences are obtained which cover all relevant linguistic phenomena and guarantee wide user acceptance in later practical use. With regard to missing integration we adapt the Integrated Deductive Approach (IDA, [23]) by designing the natural language interface as component of a deductive object-oriented database system. Therefore, we achieve a complete integration of linguistic analysis which guarantees the consistent mapping of the user input to the target representation.

A frequent argument against natural language interfaces is that for many tasks natural language is not the appropriate medium because of its verbose and ambiguous nature. Here, the integrated mix of several
interaction modes as provided by VIENA Classroom results in a multimodal interface which makes it possible to choose the appropriate mode according to the complexity of the task. Also the combination of natural language with direct manipulation techniques makes it possible to overcome some of the hard natural language problems, especially the establishment of contextual reference [5].

The applied process model displayed in Fig. 6 consists of three main modules: morphological and lexical analysis, UVL-analysis and spelling error correction as well as semantic, syntactic and pragmatic analysis.

Morphological and lexical analysis perform the tokenization of Japanese input, i.e. the segmentation of individual input words. By accessing a domain-independent lexicon, the input is transformed into a deep form list (DFL) which indicates for each token the surface form, category, sub-category and semantic deep form. For the creation of the domain-independent lexicon we adapt the lexical approach in that we store only canonical forms and assign to them all syntactic and semantic features [24]. We also support a hierarchical structure of the lexicon by making use of the inheritance mechanisms of object-oriented database technology.

The second component includes UVL-analysis and spelling error correction. UVL-analysis (short for Unknown Value List) deals with domain-specific terms that are part of the input. By separating the analysis of domain-independent and domain-specific terminology, we guarantee an easy portation of the natural language interface to other application domains. This also forms the basis for an efficient application of spelling error correction which is restricted to domain-specific terms because they are much more susceptible to the occurrence of spelling errors and also possess particular importance for the sentence meaning.

Semantic, syntactic and pragmatic analysis generate the semantic representation of the sentence by accessing the semantic application model (SAM). The SAM
provides activation rules for the selection of the correct semantic category on the basis of the DFL and UVL. If a semantic category is activated, the domain-specific terms of the UVL are used as arguments to fill the corresponding parameters of a semantic template resulting in the sentence deep structure (SDS) [25]. In the same way a generation template is applied to produce the representative question for display. In order to distinguish between arguments for which the ordering is essential for the sentence meaning and arguments for which the ordering contains no such semantic information, it is possible to add sorting rules for the latter case.

Figure 7 shows an example of semantic analysis. First, the UVL is checked if it contains the corresponding two arguments. Then, the activation rule is tested on the deep form (df) feature of the DFL. As both conditions are satisfied, the sentence deep structure and the representative question are computed by sorting the two arguments.

Syntactic analysis is only applied if necessary for disambiguation. We build the syntactic structure of the input by using a powerful extension of the Categorial Unification Grammar formalism [20]. It associates all grammar rules to constituents and performs a bottom-up parsing strategy which is in accordance with analyzing also incomplete and ungrammatical sentences efficiently. On the basis of the computed parsing trees, syntactic disambiguation rules can be tested to choose the correct interpretation.

Finally, one last important feature is pragmatic analysis which deals with the fact that questions often refer to previously mentioned questions so that important information is missing. Therefore, the scope of analysis has to be extended from the single question by keeping track of the actual focus.

As implementation platform for the natural language interface we use the deductive object-oriented database system ROCK & ROLL (Heriot-Watt University, [4]). It solves the problem of updates in deductive databases by neatly separating the declarative logic query language ROLL from the imperative data manipulation language ROCK within the context of a common object-oriented data model.

7 Conclusion

In this paper we presented the VIENA Classroom system which aims at providing a new kind of educational environment that goes beyond the limitations of traditional lectures. In particular we address the problems of personalization of teaching material to promote active individual learning and the collaborative solution of tasks to improve communication and articulation skills of the students.

The question support facility of VIENA Classroom overcomes many problems of real classrooms, e.g. the limited number of answered questions, delays in answering, the missing possibility to give priority to relevant questions or the tiring task for the teacher to answer the same kind of questions again and again. Furthermore, the system supplies important feedback for the improvement of the lecture and reduces the hesitation of the students to ask questions so that we result in a more active participation and higher motivation. Especially the flexible combination of formulating questions in Japanese and selecting a question from a list of FAQ meets the personal preferences of many students.

We have just finished the implementation of the multimodal natural language interface, the complete implementation of the other components of VIENA Classroom is still in progress. We have developed several prototypes of limited functionality to show that the chosen powerful architecture is feasible to deal efficiently with the high demands of the application.
So far, only very limited test sessions with students have been performed so that it is too early to draw final conclusions about the success of our system. Future work will concentrate on the design of an appropriate evaluation scheme to measure VIENA Classroom along the three dimensions engagement, effectiveness and viability. The evaluation will also show how the new environment will contribute to the emergence of new teaching and learning styles, i.e. we will observe which changes to the classroom management, the behavior of the students and the role of the instructor will actually occur.

We believe that VIENA Classroom will become a valuable tool for collaborative hypermedia education which will represent a tempting alternative to traditional text-book lessons by making the classes more entertaining and by giving the students the possibility to engage in exciting tasks while exploring new means of communication and information access.

References