AUTOMATIC FEEDBACK SYSTEM FOR COLLABORATIVE LEARNING USING CHATS AND FORUMS

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Abstract: Instant messaging (chat) conversations and discussion forums have become widely used in education in the last few years, especially in the context of Computer-Supported Collaborative Learning (CSCL), Self-Regulated Learning and within Communities of Practice. Nevertheless, discourse in chats with multiple participants and in discussion forums is often composed of several intertwining threads. Furthermore, several chat environments for CSCL support and encourage the existence of parallel threads by providing explicit referencing facilities. The paper proposes a discourse model for the analysis of such chat and forum discussions, based on Mikhail Bakhtin's dialogic theory. Based on this model, a system has been designed and is currently under development. It analyzes chat conversations and discussion forums for discovering implicit links between utterances that build into conversation threads. More important for CSCL is to measure the involvement and collaboration of the participants that are involved in a problem solving task. The system begins with a NLP pipe and concludes with inter-animation identification in order to generate feedback for the learners.

1 INTRODUCTION

The analysis of a regular online chat or forum may prove very difficult at this moment due to the limitations of the Natural Language Procesing (NLP) techniques, to the presence of social noise, the large number of domains that should be considered and other factors. However, this approach is useful when considering chat and forum discussions of students that are engaged in a learning activity or of experts that are trying to solve a particular problem. Furthrmore, the students are usually closely monitored by their tutors or teachers. Several studies in Computer Supported Collaborative Learning (CSCL) (Stahl, 2006) have showed that using web collaboration is useful for the students, but they seldom receive any feedback from the tutors for this kind of activities due to the difficulty of assessing them. There are two important reasons why conversation artifacts – such as chat and forum discussions – that are produced by the learners are rarely considered by tutors and teachers for evaluation (as compared to other written texts such as essays). The main reason is because the human analysis of a discussion is more difficult especially due to the existence of the inter-animating threads. Moreover, providing quality feedback to the learners is a time-consuming task. In order to tackle these problems, a previous version of the system was tested by tutors and was considered useful, reducing the analysis time per conversation by almost 50% (Rebedea & Trausan-Matu, 2009). These results have encouraged us to improve the system in order to provide feedback to both tutors and learners.

Our approach provides details on both a theoretical framework and an analysis system for online discussions of students. First, polyphony is considered as a theoretical model for a particular kind of online conversations: instant messenger (chat) conversations with multiple participants and discussion forums. The practical objective is to implement a service for analyzing such online conversations and providing feedback in order to encourage the appearance of multiple voices and of parallel threads of discussions. These aims may be obtained by catalyzing debates and inter-animation, which are premises for supporting understanding,

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studying and creative thinking of virtual teams of learners or researchers.

The implemented analysis method integrates results from Natural Language Processing (NLP) - content and conversation analysis, Social Networks Analysis (SNA) and a novel idea (Trausan-Matu and Rebedea, 2009), the identification of polyphonic threading in chats. The system was used for CSCL in assignments for computer science students. As preparation for these assignments, the students are grouped into teams of 4-7 participants and each of them has to study and to support a given topic in a chat debate. Firstly, the learners have to read some materials about that topic in order to understand the subject. During the discussions, they present their points of view, they debate and inter-animate, all of these improving their own and the others' understanding of the domain. After concluding a chat session, they can launch the system which provides graphical and textual feedback and preliminary scores both for each student and for the group as a whole. The tutors also use the system for providing them a better insight of the conversation in order to assess the results of the students and offering them a detailed feedback.

The paper continues with a section that presents the theoretical framework. The design of the feedback system is detailed in the third section and the paper ends with conclusions that offer insight in the limitations and possible improvements of the current approach.

2 INTER-ANIMATION IN ONLINE CONVSERSATIONS

Several important differences arise in discourse analysis between monologue and dialogue. While the former uses a unidirectional form of communication from speaker to listener (Jurafsky and Martin, 2009), the latter is usually modelled as a phone-like (or face-to-face) type of conversation. Typically, speech acts, dialog acts or adjacency pairs (Jurafsky and Martin, 2009) are the units of analysis. Even if there are attempts to analyze conversations with multiple participants using transacts (Dysthe, 1996, Joshi and Rosé, 2007), this approach is also based on a two interlocutors' model. For chats, TF-IDF (Adams and Martell, 2008, Schmidt and Stone), Latent Semantic Analysis – LSA (Dong, 2006), rule-based classifiers (Kontostathis et al., 2009), Social Network Analysis (Dong, 2006), WordNet (wordnet.princeton.edu) (Adams and Martell, 2008, Dong, 2006), Support Vector Machines and other classifiers (Joshi and Rosé, 2007), plus the TagHelper environment (Rosé et al., 2007) that is based on the WEKA machine learning toolkit (http://www.cs.waikato.ac.nz/ml/weka/) are have been employed for achieving several tasks: detection of topics and links (Adams and Martell, 2008), dialog acts (Kontostathis et al., 2009), lexical chains (Dong, 2006) or other complex relations like transactivity and argumentation (Rosé et al., 2007).

In phone and face-to-face dialogs at any given moment in time there is only a single speaker. Thus, the discussion is usually single-threaded. However, discussion boards and chat environments like the one used in the Virtual Math Teams (VMT) project (Stahl, 2009) offer referencing facilities. This facility is extremely important in online conversations with several participants because it allows the existence of several discussion threads or voices, in parallel. The co-occurrence of several voices gives birth to inter-animation and polyphony, phenomena identified in any text by Mikhail Bakhtin (1993). Voices may be considered as particular positions, which may be taken by one or more persons when they emit an utterance, which has explicit and implicit links and influences a part of the other voices. Thus, each utterance is filled with "overtones" of several previous utterances. In order to detect these overtones, in our system we start from explicit and implicit links and build a graph that connects the utterances and, in some cases, words or even phrases. In this graph, discussion threads may be identified. Each thread may be considered as a voice which becomes less or more powerful than the others. The graph and the threads are then used to compute several measures of contribution to the conversation regarding collaboration and inter-animation for each participant.

3 AUTOMATIC ANALYSIS OF CHATS AND FORUMS

The system has been designed as a web-service that receives an input conversation and outputs data into several web widgets that can be integrated into a LMS platform such as Moodle or a social network platform as Elgg. The input is a chat or forum log of the conversation that is stored as an XML file using a schema that was designed for encoding chat conversations and discussion forums. A pre-processing module is available that several chat

formats to a valid XML input file (e.g. Yahoo Messenger in text format, other text format chats, VMT html format).

The output provided by the system contains numerical, textual and graphical feedback for the tutors and learners, including the following:

- The list of most important (used, discussed) concepts in a chat / forum, considering semantic similarities between the concepts;
- The coverage of the important concepts specified by the tutor;
- A score for each utterance in the conversation;
- A score for each participant in the conversation;
- The most important utterances of each participant (the ones with the largest scores – the score for an utterance uses a complex formula that takes into account the concepts used, dialog acts, the links between utterances and SNA factors);
- Dialogue and argumentation acts identified in each utterance / post;
- Portions of the conversations with important collaboration (argumentation, convergence and divergence);
- Social Network Analysis (SNA) scores like: centrality degree, input and output degree PageRank, etc.;
- Graphics with the evolution of the scores of the participants during the chat conversation;
- Module for the visualization of the conversations graph with filtering enabled;
- Other indicators and statistics that are going to be added with the development of the service / system.

Figure 1 presents the technical architecture of the system which consists of several layers as described below:

1. Firstly, the data is processed by a **NLP pipe** (spelling correction, stemmer, tokenizer, POS tagger, NP chunker);
2. In the **Semantic sub-layer**: concepts are searched in a linguistic ontology (e.g. Wordnet) and a list of key concepts (or a domain ontology). In addition, LSA may be used as alternative to ontologies. Other technologies can also be used for computing the semantic similarity between concepts – for example Wikipedia-based similarity measures (Ponzetto and Strube, 2007).
3. **Advanced NLP and discourse analysis techniques** (the identification of speech acts, lexical chains, adjacency pairs, co-references, discussion threads, etc.) are used in order to find out interactions among the participants;
5. **Polyphony sub-layer** uses the interactions and advanced discourse structures to look for convergence and divergence and polyphonic inter-animation;
6. **Social Network Analysis** by taking into account the social graph induced by the participants and interactions that have been discovered.
7. **Combine the results** of the previous sub-layers to offer textual and graphical feedback and a grade proposal for each participant to a chat or forum discussion.

Figure 2 offers an overview of the functionality of the system and specifies the most important communication between the modules using arrows. The key modules are presented in more detail in the following subsections.

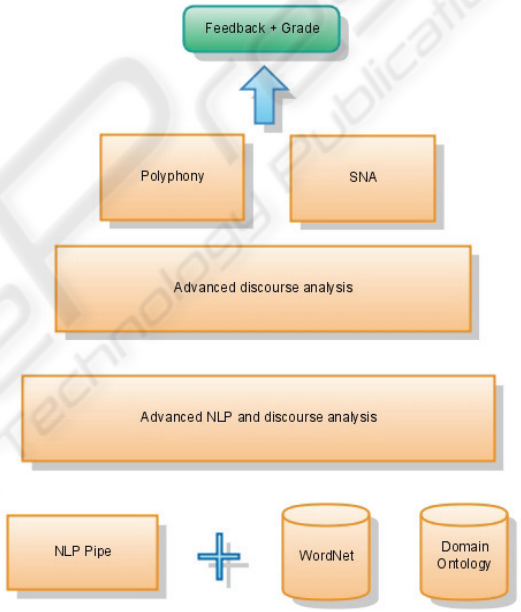

Figure 1: The layered architecture of the feedback system.

3.1 The NLP Pipe and Pattern Language for Conversations

The first step of the processing is done by a NLP: spelling correction, stemmer, tokenizer, Named-Entity recognizer, POS tagger and parser, NP-chunker. The modules in the NLP pipe are mainly those provided by the Stanford NLP software group (http://nlp.stanford.edu/software), with the exception of the spell checker (implemented using Jazzy, see http://jazzy.sourceforge.net/). Two alternative NLP pipes are under development, integrating modules from GATE and LingPipe.

A special module, called PatternSearch was implemented for searching occurrences that match particular expressions a conversation. This module is

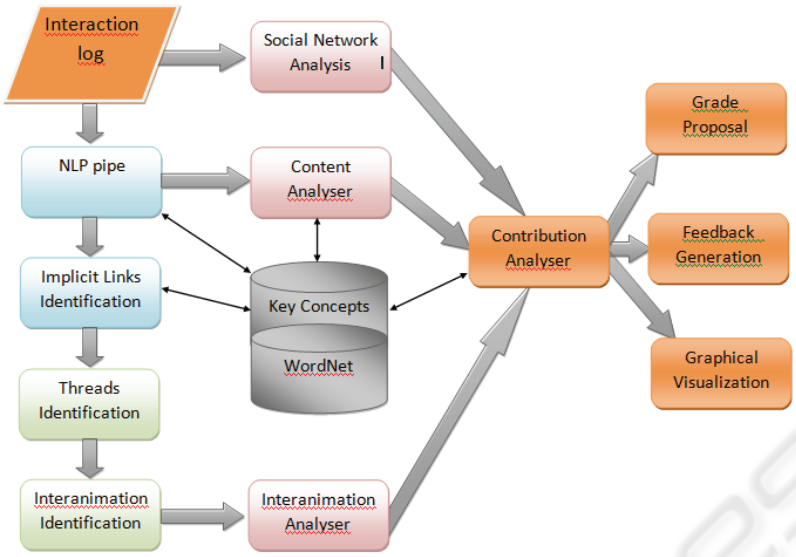

Figure 2: Main modules of the analysis and feedback system.

used for several other tasks: cue-phrases identification, implicit links identification and adjacency pairs identification. Furthermore, it is used by the tutors and teachers to search for particular patterns that are considered important.

In addition to a simple regular expression search, the module allows considering not only words, but also synonyms (e.g. using the pattern <*S "word"*>), hypernyms and hyponyms via WordNet, words' stems (the pattern <*D "stem"*>) and their part of speech (the patterns <*NN*>, <*NNS*>, <*VB*>, etc.). Another novel facility is the consideration of utterances as a search unit, for example, specifying that a word should be searched in the previous n utterances and that two expressions should be in two utterances.

For example, the expressions <*S ref[10]*> implies finding the utterances that contain a synonym to a word that appeared in the previous 10 utterances. Even more complicated expressions can be built using variables, negation, conjunctions and disjunctions of clauses, plus the precedence operator #. Thus, the expression:

```
<S "convergence"> #[*] cube
```

searches pairs of utterances that have a synonym of "convergence" in the first utterance and "cube" in the second. One result from a particular chat is the pair of utterances 1103 and 1107:

```
1103 # 1107. overlap # cube [that would stil have to acount for the overlap that way] # [an idea: Each cube is assigned to 3 edges. Then add the edges on the diagonalish face.]
```

The search is made at utterance level - the program checks the utterances one by one (and if there is a match between a part of the utterance and the searched expression, both the utterance and the specific text that matched are indicated).

3.2 Content-based Analysis

The content analysis identifies the main concepts of the chat or forum using the NLP pipe, cue-phrases and graph algorithms. It also identifies speech acts derived from DAMSL (Allen and Core, 1997) and argumentation types in utterances, as in Toulmin's theory (1958). Concepts are searched in the lexical database Wordnet (wordnet.priceton.edu) and in a collection of key concepts and their inter-relations for the subject, provided by the teacher. If a domain ontology is also provided, the system uses it to find concepts that have a high measure of similarity.

Furthermore, advanced NLP and discourse analysis identify various types of implicit links:

- Repetitions (of ordinary words or Named Entities);
- Lexical chains, which identify relations among the words in the same post / utterance or in different ones, by using semantic similarity measured based on WordNet (the semantic sub-layer);
- Adjacency pairs (Jurafsky and Martin, 2009) – pairs of specific speech acts – answers to a single question in a limited window of time (in which the echo of the "voice" of the question remains), greeting-greeting;

- Co-references (the BART system (Versley et al., 2008) is used – see http://bart-coref.org/)

3.3 Words, Voices, Threads, Inter-animation and Collaboration

In the implementation of our analysis tool, we start from the key concepts and associated features that have to be discussed and that are provided by the teacher. Each participant is assigned to support a position which corresponds to a key concept. Implicitly, that corresponds to a voice emitting that concept and the associated features. We may identify other, additional voices in the conversation by detecting recurrent themes, new concepts. Therefore, a first, simple perspective is to have a word-based approach on voices: We consider that a repeated word (that is a noun, verb, adjective or adverb) becomes a voice. The number of repetitions and some additional factors (e.g. presence in some specific patterns) may be used to compute the strength of that voice (word).

Voices continue and influence each other through explicit or implicit links. In this perspective, voices correspond to threads. A thread may be a reasoning or argumentation chain (Toulmin, 1958), a chain of rhetorical schemas, chains of co-references, lexical chains and even only chains of repeated words. The identification of argumentation chains, rhetorical schemas or co-references in texts and conversations are very difficult tasks for Natural Language Processing. Chains of repeated words, however, are very easy to detect, the sole problem being the elimination of irrelevant repeated words. Lexical chains can also be detected very easy, but their construction is more difficult and the resulted lexical chains are greatly influenced by the choice of the ontology and similarity measures.

The evaluation of the contributions of each learner considers several features like the coverage of the expected concepts, readability measures, the degree to which they have influenced the conversation or contributed to the inter-animation. In terms of our polyphonic model, we evaluate to what degree they have emitted sound and strong utterances that influenced the following discussion, or, in other words, to what degree the utterance became a strong voice.

The automatic analysis considers the inter-animation patterns in the chat. It uses several criteria such as the presence in the chat of questions, agreement, disagreement or explicit and implicit referencing. In addition, the strength of a voice (of an utterance) depends on the strength of the utterances that refer to it. If an utterance is referenced by other utterances that are considered important, obviously that utterance also becomes important.

By using this method of computing their importance, the utterances that have started an important conversation within the chat, as well as those that began new topics or marked the passage between topics, are more easily emphasized. If the explicit relationships were always used and the implicit ones could be correctly determined in as high a number as possible, then this method of calculating the contribution of a participant would be considered (Trausan-Matu and Rebedea, 2009).

The implemented system supports the analysis of collaboration among learners: It produces different kinds of information about discussions in chat and forum discussions, both quantitative and qualitative, such as various metrics, statistics and content analysis results such as the coverage of the key concepts related to executing a task and the understanding of the course topics or the inter-threaded structure of the discussion. In addition, the system provides feedback about the involvement of each learner, generates a preliminary assessment and visualizes the interactions and the social participation. Finally, the system identifies the most important chat utterances or forum posts (that express different opinions, missing topics/concepts, misleading posts, misconceptions or wrong relations between concepts).

The results of the contribution analyzer are annotated in the XML file of the chat or forum. The annotations are associated to feedback provided for utterances, for the participants or for the conversation as a whole.

As graphical feedback, the service provides interactive visualization and analysis of the conversations graph with filtering enabled. The graphical representation of chats was designed to facilitate an analysis based on the polyphony theory of Bakhtin and to permit the best visualization of the conversation. For each participant in the chat, there is a separate horizontal line in the representation and each utterance is placed in the line corresponding to the issuer of that utterance, taking into account its positioning in the original chat file – using the timeline as an horizontal. Each utterance is represented as a rectangular node having a horizontal length proportional with the textual length of the utterance. The distance between two different utterances is proportional to the time between the utterances (Trausan-Matu and Rebedea, 2009).

4 CONCLUSIONS

A new theory, inspired from Bakhtin's ideas was proposed for explaining and evaluating collaboration and inter-animation in chat and forum discussions. Its main idea is the consideration of intertwining of discussion threads similarly with counterpoint in polyphonic music. Graphical visualization and various metrics are computed using a wide range of NLP and SNA techniques.

Although the first experiments with the system showed that the polyphony model is useful for providing feedback to the tutors to understand better the inter-animation and collaboration processes, further testing is necessary to determine its relevance for the learners and whether the results it provides influences their behaviour. Moreover, some of the linguistic components have to be improved in order to provide a more accurate result.

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