Visualisation of Learners' Contributions in Chat Conversations

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Abstract. In this paper is presented a novel dialogistic, socio-cultural perspective and an associated software tool, which provide structured visualisation and analysis means of Computer Supported Collaborative Learning chat conversations. The implemented tools use knowledge-based techniques and are based on Bakhtin's dialogistic paradigm. They visualize the threading of topics and utterances in the conversation and the contributions of the participants in collaborative learning during instant messenger chats. Natural language processing based on the WordNet lexical ontology and semantic distances are used for detecting topics in the chat and their threading. The experiments with the developed application were performed with students at a course on Human-Computer Interaction in Bucharest Politehnica University.

Keywords: Computer Supported Collaborative Learning, Dialogism, Chat Conversations, Ontologies, Natural Language Processing

1 Introduction

In recent years, in conjunction with the omnipresence of the Internet and to the increasing number of collaborative tools like discussion forums and instance messaging (chat conversations), Computer Supported Collaborative Learning (CSCL) became an extending and promising way of learning on the Internet, which could supplement traditional classroom learning. However, CSCL needs particular supporting tools, for example for tackling and reviewing complex dialog threads in collaborative learning in small groups using chat conversations. The paper describes such a tool, that offers visualisation means to analyse the threading of dialog topics and the contribution of each learner in a chat conversation.

A theoretical background for developing tools for supporting CSCL using chat conversations is the socio-cultural paradigm, stating that knowledge is socially built in communities [7] (including the case of small groups of students that learn together).

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This new paradigm is imposing itself not only due to technology advances but also because the individual cognition perspective of classical artificial intelligence (stating that knowledge should be considered as being in the mind of individuals) did not fulfil all its expectations [4,14]. However, knowledge-based technology, combined with natural language processing, has some important applications (e.g. in text mining) and we should not throw away its potential facilities. Therefore, the approach presented in this paper is integrating both the knowledge-based (ontology-based), cognitive paradigm and the socio-cultural one.

Learning paradigms have also changed in a similar way, from Computer-Assisted Instruction and Intelligent Tutoring Systems to Computer-Supported Collaborative Learning (CSCL) [4,7]. As a consequence, learning is now conceived as discourse building, as Sfard remarked: "rather than speaking about 'acquisition of knowledge,' many people prefer to view learning as becoming a participant in a certain discourse" [6]. The way learning is considered has implications on the nature of the computer tools designed to support it. For example, the tools described in this paper, which offer the possibility of visualising the discourse in chat conversations, are based on Bakhtin's dialogistic theory [1,2], which may be seen as extending Vygotsky's socio-cultural ideas [12]. Knowledge-based processing techniques and the lexical ontology WordNet (http://wordnet.princeton.edu) are used for the identification, delimitation and visualisation of the inter-animation of the voices of the learners. In addition, an assessment of the competence of each learner is provided.

There are chat environments for CSCL containing facilities like whiteboards and explicit referencing. Such an environment is ConcertChat [3], used in this paper. There are also applications that use natural language processing for abstracting (e.g. speech acts identification [9] and summarization [10]) or knowledge extraction from chats and forums. However, these facilities are limited, and one assumption of the research whose results are presented here is that the limitations are due to the neglecting of the socio-cultural paradigm.

The experiments for validating the developed application were performed with students from the final year at the Computer Science Department of the Bucharest Politehnica University, at a course on Human-Computer Interaction. For performing the chat conversation, the ConcerChat was used.

The paper continues with a section introducing the socio-cultural and Bakhtin's dialogism paradigms. The third section discusses the knowledge-based ideas used in the present approach. The next section contains the description of the visualisation tools. The paper ends with conclusions and references.

2 A Dialogical, Socio-Cultural Paradigm of Learning

The socio-cultural paradigm is based on the work of the Russian psychologist Lev Vygotsky, who emphasized the role of socially established artefacts in communication and learning [12]. Mikhail Mikhailovici Bakhtin brought a lot of details to the ideas of Vygotsky, analysing the role of language and discourse, and especially of speech and dialog. Bakhtin focuses on the idea of dialogism, making it a fundamental philosophical category, named dialogistic: "… Any true understanding is

dialogic in nature." [11]. Moreover, Lotman considers text as a „thinking device" [13], determining that: "The semantic structure of an internally persuasive discourse is not finite, it is open; in each of the new contexts that dialogize it, this discourse is able to reveal ever new ways to mean" [2].

In forums and chat conversations, group knowledge arises in discourse and is preserved in linguistic artifacts, whose meaning is co-constructed within group processes [5], and has a dual nature. Communities of voices, in parallel to the trend towards unity, have an additional differential, *unmerged*, character: "The *intersection, consonance, or interference of speeches in the overt dialog with the speeches in the heroes' interior dialogs* are everywhere present. *The specific totality of ideas, thoughts and words* is everywhere *passed through several unmerged voices, taking on a different sound in each"* [1]. This dual nature of community and individuality of voices is expressed by Bakhtin also by the concept of *polyphony*, that he considers the invention and one of the main merits of Dostoevsky novels [1]. The relation of discourse and communities to music was remarked also by Tannen: "Dialogue combine with repetition to create rhythm. Dialogue is liminal between repetitions and images: like repetition is strongly sonorous" [8].

In chat conversations, different voices are obvious recognized. However, starting from Bakhtin's ideas, in our approach the concept of voices is not only limited to the number of participants in the chat. A voice is, from this perspective, something said by a participant in a given moment and that it may be reflected in many subsequent utterances. Also, each utterance may contain an unlimited number of voices.

3 Knowledge-Based Text Processing

Ontologies like WordNet or FrameNet (http://framenet.icsi.berkeley.edu) are very successful inheritors of knowledge representation research in artificial intelligence. They are semantic networks or frame structures built starting from human experience and, in fact, they are ways of sharing experience. Any collaboration using natural language, any discourse needs to start from a common vocabulary, a shared ontology.

The word "ontology" is used in philosophy to denote the theory about what is considered to exist. Any system in philosophy starts from an ontology, that means from the identification of the concepts and relations considered as fundamental. Ontologies capture fundamental categories, concepts, their properties and relations. One very important relation among concepts is the taxonomic one, from a more general to a more specific concept. This relation may be used as a way of "inheriting" properties from the more general concepts ("hypernyms"). Other important relations are "part-whole" ("meronym"), "synonym", "antonym".

Viewing knowledge bases as ontologies determines important advantages for developers of knowledge-based systems. First of all, an ontology is developed as a coherent framework for the reality and therefore it facilitates knowledge acquisition and machine learning. A new concept is easy to add in such a framework by finding one or some more general concepts and defining some differences between the new concept and the more general ones.

Ontologies are very important in text mining. For these kind of applications they offer the substrate for semantic analysis and, very important, the possibility of defining a measure of semantic closeness, based on the graph with concepts from ontologies as nodes and their relations as arcs. This semantic closeness is very important in text analysis for example in the retrieval of texts that do not contain a given word, but they contain a synonym or a semantically related word.

4 Visualization of Users' Competences

The approach presented here integrates Bakhtin's socio-cultural ideas with knowledge-based natural language processing for the visualisation of the contributions of each learner. The procedure consists in the identification of the topics discussed in the chat, the separation of the contributions of each participant to a topic (the voices) and, eventually, the measurement and visualisation of these contributions.

4.1 Identification of Chat Topics

The chat topics are identified in several ways in the present approach. A first method id to detect the list of concepts (words) that appeared most frequently in the conversation, by using statistical natural language processing methods. Accordingly, the importance of a subject is considered related to its frequency in the chat. The first step in finding the chat subjects is to strip the text of irrelevant words (stop-words), text emoticons (e.g. ":)", ":D", and ":P"), special abbreviations used while chatting (e.g. "brb", "np", and "thx") and other words considered of no use at this stage.

85	andrei	right ?	15.12.2006	10.32.39	
86	Florin	and can send their comments, like: its working, not!	15.12.2006	10.33.09	Reference to message No. 85 (Text: "right ?")
87	Anca	Do I really want any employ to be able to read about my problem and the solution?	15.12.2006	10.33.19	Reference to part of the message No: 84 (Text: "and the employers could read the pos")
88	Florin	if you have seen borat	15.12.2006	10.33.19	Reference to message No. 86 (Text: "and can send their comments, like: its working, not!")
89	andrei	only that employers who have some permissions ...	15.12.2006	10.33.56	Reference to message No. 87 (Text: "Do I really want any employ to be able to read about my problem and the solution?")
90	andrei	i guess	15.12.2006	10.34.10	
91	Florin	I dont think you can set permissions	15.12.2006	10.34.24	Reference to message No. 90 (Text: "i guess")
92	andrei	why not ? you can give level permisions	15.12.2006	10.34.58	Reference to message No. 91 (Text: "I dont think you can set permissions")
93	Anca	what if the company has been sued regarding a certain legal issue and the legat departement has found a proper solution for the trial?	15.12.2006	10.35.09	Reference to part of the message No: 89 (Text: "only that employers who have some permissions ")
94	Anca	I may not want every employ to find out about this	15.12.2006	10.35.32	

Fig. 1. A fragment of a chat for a Human-Computer Interaction course, using the ConcerChat facilities of referencing

The resulted chat text is then tokenised and each different word is considered as a candidate concept in the analysis. For each of these candidates, WordNet is used for finding synonyms. If a concept is not found on WordNet, mistypes are searched. If successful, the synonyms of the suggested word will be retrieved. If no suggestions are found, the word is considered as being specific to the analyzed chat and the user is

asked for details. The last stage for identifying the chat subjects consists of unifying the candidate concepts discovered in the chat.

In addition to the above method for determining the chat topics, a surface analysis technique is used. Observing that new topics are generally introduced into a conversation using some standard expressions such as "let's talk about email" or "what about wikis", a simple and efficient method is used for deducing the topics in a conversation by searching for the moment when they are first mentioned.

The process of identifying a pattern in an utterance is done using the synset for each word that has already been extracted from WordNet. This technique will be improved in a future version of the application by using machine-learning methods for detecting the patterns specific to the introduction of new topics. Another option is to consider the extension of the simple patterns described above to more complicated parsing rules.

4.2 The Graphical Representation of the Conversation

The graphical representation of the chat was designed to permit the best visualization of the conversation, to facilitate an analysis based on the polyphony theory of Bakhtin, and to maximize the straightforwardness of following the chat elements. 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 axis. Each utterance is represented as a rectangle aligned according to the issuer on the vertical axis and having a horizontal axis length that is proportional with the dimension of the utterance. The distance between two different utterances is proportional with the time passed between the utterances. Of course, there is a minimum and a maximum dimension for each measure in order to restrict anomalies that could appear in the graphical representation due to extreme cases or chat logging errors.

The relationships between utterances are represented using coloured lines that connect these utterances. The explicit references that are known due to the use of the ConcertChat software are depicted using blue connecting lines, while the implicit references that are deduced using the method described in this paper are represented using red lines. The utterances that introduce a new topic in the conversation are represented with a red margin.

The graphical representation of the chat has a scaling factor that permits an attentive observation of the details in a conversation, as well as an overview of the chat. The different visual elements determined by our application – such as utterances in the same topic, topic introducing utterances and relationships between topics – can be turned on and off in the graphical representation by use of checkboxes.

At the bottom of the graphical representation of the conversation, after the line corresponding to the last participant in the chat, there is a special area that represents the importance of each utterance, considered as a chat voice, in the conversation (see figure 2). How this importance is determined is presented in a further section.

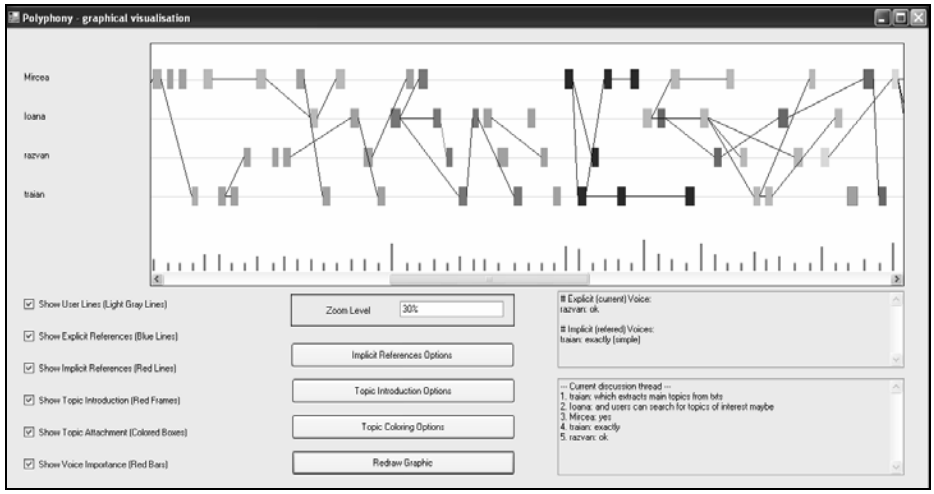

Fig. 2. The threads of references in the chat

4.3 Discovering the Implicit Voices

Considering each chat utterance as being a voice that has a certain importance in the conversation, it is obvious that each utterance generally contains more than a single voice, as it includes the current voice and probably at least one referring voice. As we are working with ConcertChat transcript files, we acknowledge the voices that are explicitly pointed out by the chat participants during the conversation, using the software's referencing tool. Nevertheless, because users are seldom in a hurry or simply not attentive enough, part of the utterances do not have any explicit references. Thus, it is necessary to find a method for discovering the implicit references in an utterance; in this way, we shall identify more relationships between the utterances in the chat.

The method proposed here is similar to the one presented above for determining the introduction of new chat topics. We are using another list of patterns that consists from a set of words (expressions) and a local subject called the referred word. If we identify that an utterance matches one of the patterns, we firstly determine what word in the utterance is the referred word (e.g. "I don't agree with your assessment"). Then, we search for this word in the predetermined number of the most recent previous utterances. If we can find this word in one of these utterances, then we have discovered an implicit relationship between the two lines, the current utterance referring to the identified utterance.

We have also implemented two empirical methods, which provide very good results when utilizing any chat software. One of these empirical methods is based on the following fact: if between three utterances there are two explicit relationships from the first to the second and from the second to the third and the second utterance is a short agreement or disagreement, then between the first and the third utterance there exists an implicit relationship. For example, consider the following example,

where there are explicit references between A and B, respectively B and C, it is clearly we have an implicit relationship between A and C. In the last utterance, we have influences from both A and B:

A – I think wikis are the best
(…)
B – I disagree *REF A*
(…)
C – Maybe we should talk about them anyway *REF B*

4.4 Determining the Strength Value of an Utterance

Starting from existing references within the analysed conversations, both those explicit, offered by the used chat environment, as well as those implicit determined by the program using the previously presented methodology, one could assemble a conversation graph. This graph may be used both for determining the strength value of each utterance in the chat considered as a separate voice, as well as for emphasizing certain subjects (threads) of the conversation.

The importance of an utterance in a conversation can be calculated through its length and by the number of key (important) words. Another approach was also investigated: an utterance is important if it influences the subsequent evolution of the conversation. Using this definition as a starting point, we may infer that an important utterance will be that utterance which is a reference for as many possible subsequent utterances.

Even if this approach could be extended to include the types of subsequent references (implicit or explicit, agreements or disagreements), in the present case we have preferred a more simplistic approach, without making allowances for the types of references to the utterance.

Consequently, the importance of an utterance can be considered as a strength value of an utterance, where an utterance is strong if it influences the future of the conversation (such as breaking news in the field of news). When determining the strength of an utterance, the strength of the utterances which refer to it is used. Thus, if an utterance is referenced by other utterances which are considered important, obviously that utterance also becomes important.

As a result, for the calculation of the importance of every utterance, the graph is ran through in the opposite direction of the edges, as a matter of fact in the reverse order of the moment the utterance was typed. Utterances which do not have references to themselves (the last utterance of the chat will certainly be one of them) receive a default importance – taken as the unit. Then, running through the graph in the reverse order of references, each utterance receives an importance equal to that of the default plus a quota (subunit) from the sum of the importance of the utterances referring to the current utterance. Another modality to calculate could be 1 plus the number of utterances that refer to the present utterance, but this choice seemed less suitable.

By using this method of calculating the importance of an utterance, the utterances which have started an important conversation within the chat, as well as those

utterances which begin new topics or mark 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 importance of a voice would be successful.

4.5 Assessing the Competencies of the Learners in the Conversation

In order to determine the competences of the chat users, we first searched the most important topics in the analyzed chat conversation. The generated graphics evaluate the competences of each user, starting from the list of subjects determined as explained above and using other criteria such as questions, agreement, disagreement or explicit and implicit referencing. The graphics are generated using a series of parameters like: implicit and explicit reference factors, bonuses for agreement, penalties for disagreement, minimum value for a chat utterance, penalty factors for utterances that agree or disagree with other utterances as these utterances have less originality than the first ones.

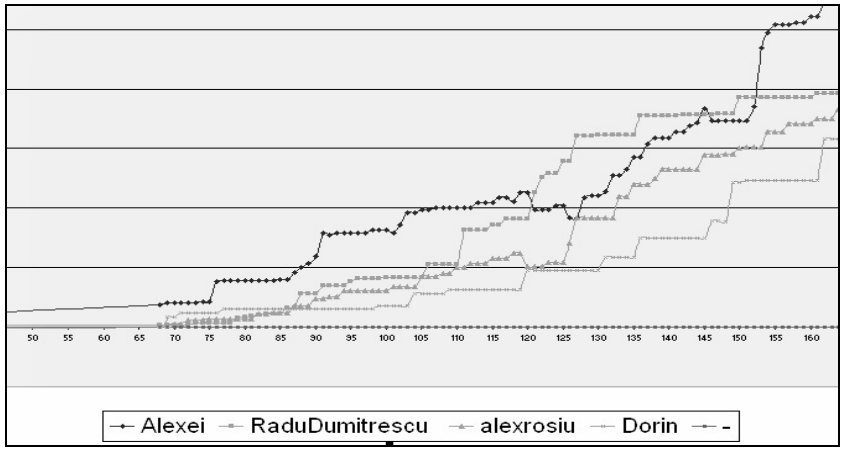

Fig. 3. The evolution of the competence degree

During the first step of the graphics generation, the value of each utterance is computed by reporting it to an abstract utterance that is built from the most important concepts in the conversation determined as described above. When constructing this utterance, we take into account only the concepts whose frequency of appearance is above a given threshold. Then, all the utterances in the chat are scaled in the interval 0 – 100, by comparing each utterance with the abstract utterance. The comparison is done using the synsets of each word contained in the utterance. Thus, this process uses only the horizontal relations from WordNet. An utterance with a score of 0 contains no words from the concepts in the abstract utterance and an utterance with a score of 100 contains all the concepts from the abstract utterance.

On the Ox axis the graphics hold all the utterances in the chat and on the Oy axis the value attributed to each participant in the conversation, representing each user's

competence (see figure 3). Accordingly, for each utterance, at least the value of a user competence is modified – the value for the user that issued that utterance.

For each utterance in the chat, the values of the users' competences are modified using the following rules:

1) the user that issued the current utterance receives the score of the utterance, eventually downgraded if that utterance is an agreement or disagreement in relation to a previous utterance (in order to encourage originality);

2) all the users that are literally present in the current utterance are rewarded with a percentage of the utterance value, considering that they have some merit in the value of this utterance, as being mentioned in the text of the utterance encourages us to think so;

3) the issuer of the utterance explicitly referred to by the current utterance is rewarded if this utterance is an agreement and is penalized if the utterance is a disagreement;

4) the issuer of the utterance explicitly referred to by the current utterance that is not an agreement or a disagreement, will be rewarded with a fraction of the value of this utterance; and

5) if the current utterance has a score of 0, the issuer will receive a minimum score in order to differentiate between the users that actually participate in the chat and those who do not.

All the percentages and all the other factors used for computing the competence of each user are used as parameters of the process and can be easily modified in the application interface. The process described above builds competence function graphics for each participant in the chat. At the start of the process, each user has a null competence. It should be mentioned that the competence of a user is not a strictly increasing function, as users are penalized for *utterances* that are in disagreement with the other users' opinions.

5 Conclusions

The paper presents an application that visualizes the voices (following Bakhtin's ideas) of the participants on forums or chat conversations, similarly to music scores. In addition, some other diagrammatic representations are used for viewing the influence of a given speaker's voice.

The application may be used for inspecting what is going on and in what degree learners are implied in a forum discussion or a chat conversation. Moreover, the competence of each participant may be measured, that means that learners may be assessed in collaborative learning on the web.

The application uses the WordNet ontology. Knowledge acquisition for concepts that are not present in this ontology is provided through dialogs with the user of the analysis system and by caching the results. Natural language technology is used for the identification of discussion topics, for segmentation and for identifying implicit references.

Further work will consider more complex semantic distances (than only synonymy). Machine learning techniques will be used for the identification of

discourse patterns. New rules for the identification of implicit links are now under development.

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