Towards Representation of the Discourse Structure Leading to Consensus

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Abstract. Consensus is the desired result in many argumentative discourses such as negotiations, public debates, and goal-oriented forums. This paper presents a summary of the work dedicated to investigating of discourse structure in order to determine rhetorical structures that lead to consensus. In addition we investigated language patterns extracted from the data collection in order to discover which ones are indicators of the following agreement.

Keywords: discourse analysis, rhetorical relations, consensus building

1 Introduction

Since computer and web technologies offer vast opportunities for public debates, collaborative discussions, negotiations etc., the issue of consensus building within discourse has become more substantial. In computational linguistics there have been numerous studies dedicated to discourse analysis, modelling and analysis of collaboration, negotiations and agreement process [5], [6], [7], [18].

Two important components of discourse studies are the representation of discourse structure and language. We investigated discourse structure in attempt to find out how it can reflect successful or unsuccessful discussion. In this particular study we thought of a discussion as successful if participants achieve agreement about a statement. Our aim was to determine if there exist structures of discourse that lead to consensus and structures that do not lead to consensus. We think definition of such type of structures could help for better understanding of position and intentions of participants during agreement process. We performed our study using web-discussions (Wikipedia Talk pages, English language), where participants had as their goal to agree upon editing policy of Wikipedia articles. To build the discussion structure we used Rhetorical Structure Theory (RST) relations. We then applied statistical analysis to our discussions annotated with 918 relations.

As mentioned above, another important component of discourse analysis is language or better say, those words and phrases used by the participants to directly indicate the structure of the argument to the other participants. Thus we next investigated how language reflects success or failure in our web-discussions [18].

2 Related Works

There have been a number of researches of modelling and analyzing negotiation and agreement process in computational linguistics. In [5] multiagent collaborative planning discourse is analyzed and an artificial language is formulated for modeling such discourse. Modeling is done using proposal/acceptance and proposal/rejection sequences. Propose-Evaluation-Modify framework for collaboration is proposed in [6]. Slightly different approach to the problem of modeling of agreement process is described in [7]. They model their participant's collaborative behavior according to Balance-Propose-Dispose agreement process and they focus on how information is exchanged in order to arrive to a proposal and what constitutes a proposal and it acceptance or rejection. We proposed to build discourse structure using RST and basing on empirical analysis, to determine which types of discourse structures are leading to final consensus. In [18] the preliminary study investigates how language reflects success or failure of electronic negotiations. They seek text characteristics which can help in prediction of negotiations success or failure. Using NLP and ML techniques they show how language differs in successful and failed negotiations. Thus we have also analyzed the discussion language in order to identify language features that influence the result in our discussions.

3 Web-Discussions Annotated with Rhetorical Relations

We stopped at Wikipedia discussions for two reasons: 1) these are web-mediated discussions; 2) these are task-oriented discussion - the purpose of each discussion is to achieve agreement about the final version of Wikipedia article; since we aimed to define discourse structures that lead to consensus, we considered these discussions to be suitable for our study.

3.1 Rhetorical Relations

Rhetorical Structure Theory is descriptive theory of hierarchical structure in discourse that identifies functional relationships between discourse parts based on the intentions behind their production [8]. In this study we present 'discourse part' as participants' statements. Since one statement may contain different types of information; we segmented the statements into segments corresponding to *speech acts*. According to the definition, *speech act* is a term that refers to the act of successful communicating an intended understanding to the listener. Each speech act within one user's statement has a separate speech function like asking question, explaining, etc. One speech act can be related to one or more other speech acts. So in this study, 'discourse parts' equivalent to *speech acts* become the *elementary segments* for annotation.

Although the application of RST for different types of conversational analysis is not novel, there is no common agreement on the application policy. The set of applied rhetorical relations is dependent on the purpose of the discourse analysis. We adapted

the original RST set of relations to create our own tag set that we called *argumentation specific* rhetorical relations tag set.

The kinds of argumentation specific relations we used include Consensus relations *Agreement/Disagreement*, for example in (1) segment B states the agreement with the previous discussion segment A:

(1) Agreement

A: There is no official language of the United States. The correct answer to the question "What is the official language of the United States?" is "none".

B : I agree with Nunh-huh.

We also introduce Question relations that in our opinion are necessary to connect question-answer pairs and help to determine the question intention, like in example (2), where relation *Require yes/no* is used to clarify the question intention stated in segment B :

(2) Require yes/no

A: The previous poster was absolutely correct. It needs to be permanently changed ASAP.

B: You want us to lock the page?

Our collection of web–discussions contained 1764 statements (participants' comments), the total number of participants was 506 and we obtained 918 rhetorical relations connecting the statements. We had only one annotator who annotated our discussions with the help of the annotation tool. The tool allows diagramming of the discussion structure. The annotation was done in two steps. First, the annotation tool structured the discussion into separated statements stated by various participants of the discussion. Then, using the list of the rhetorical relations proposed by the tool, annotator connected participants' statements. One of the issues that arose during the annotation process was the ambiguity problem, when for one statement's context more than one rhetorical relation definition was possible to apply. In some cases, the relation Unknown was used, as it was difficult to apply any rhetorical relation definition. In the Table 1 below we present our tag set of 27 rhetorical relations.

Table 1. Rhetorical relations tag set.

Affirmation	Require evidence	Solution
Negation	Require detail	Warning
Evidence	Require yes/no	Concession
Justification	Request to do	Summary
Elaboration	Suggestion	Unknown
Explanation	Apology	Response
Background	Accusation	Addition
Example	Gratitude	
Agreement	Ironic_comment	
Disagreement	Offence	

3.2 Defining Discourse Structure that Leads to Consensus

We based on a simple assumption that within consensus building process discourse structure is regarded as successful, when there is a tendency for agreement. To formulate the assumption, we modeled our discourse as an oriented graph with nodes representing statements and arcs representing rhetorical relations that hold between statements. We supposed that it is possible to define successful discourse structure with help of sequences of rhetorical structures that hold between statements of the discussion. Here, we call these structures *agreement oriented*. For example, we presumed that the discourse sub-graph structures *Require evidence/Evidence* and *Evidence/Agreement* could be regarded as successful structures. In addition, we supposed that in successful discussions such rhetorical structures as *Evidence/Agreement* will be more frequent than let's say *Evidence/Disagreement* or *Suggestion /Agreement*.

Such heuristics needs to be verified empirically. So the validity of our assumptions will be observed from the further analysis of the discussion structures and shown in analysis results.

4 Rhetorical Structures Analysis

To verify the assumptions, we analyzed our data with help of so called sequence-based analysis. We counted frequency of rhetorical relations bigrams for *Agreement* (*Disagreement*) pairs and calculated priori

$$P(r2|r1)=C(r1,r2)/C(r1) \tag{1}$$

and posterior

$$P(r1|r2)=C(r1,r2)/C(r2). \tag{2}$$

probabilities, where, $C(r)$ and $C(r1,r2)$ denote frequencies of a rhetorical relation r and relation bigram $(r1,r2)$, respectively. These calculations enabled us to identify rhetorical relations that most frequently precede *Agreement* and *Disagreement*. The results are presented in Table 2 and Table 3. Order of relation r1 in the tables is sorted by $P(r1|r2= Agreement)$, the posteriori probability of r1 when r2=Agreement, because this probability can be regarded as a contribution of r1 for building consensus.

From the tables 2 and 3 it can be seen that most frequent Agreement pairs had *Evidence* as the relation that was followed by *Agreement*. The most frequent Disagreement pairs had *Suggestion* as the relation that was followed by *Disagreement*. Also the frequency of the pairs *Evidence/Disagreement* is higher than *Evidence/Agreement*.

Next we applied Evidence-based analysis to investigate the influence of contribution (on this stage it is *Evidence*) relation on final agreement. The contribution relation r1 is a target relation for analyzing its influence on final consensus relation.

Table 2. Priori and posteriori probability for most frequent Agreement pairs.

Relation r_1	$P(r_2=\text{Agreement}|r_1)$		$P(r_1|r_2=\text{Agreement})$	
Evidence	0.176	(12/68)	0.072	(12/166)
Suggestion	0.170	(19 / 112)	0.114	(19/ 166)
Disagreement	0.133	(22 / 166)	0.133	(22/ 166)
Agreement	0.120	(20 / 166)	0.120	(20/ 166)
Answer	0.138	(4 / 29)	0.024	(4 / 166)
Explanation	0.107	(18 / 169)	0.108	(18/ 166)
Req_evidence	0.082	(4 / 49)	0.024	(4 / 166)
Justification	0.021	(1 / 47)	0.006	(1 / 166)

Table 3. Priori and posteriori probability for most frequent Disagreement pairs.

Relation r_1	$P(r_2=\text{Disagreement}|r_1)$		$P(r_1|r_2=\text{Disagreement})$	
Evidence	0.221	(15/ 68)	0.090	(1 / 166)
Suggestion	0.277	(31/ 112)	0.187	(31/ 166)
Disagreement	0.127	(21/ 166)	0.127	(21/ 166)
Agreement	0.024	(4/ 166)	0.024	(4 / 166)
Answer	0.034	(1/ 29)	0.006	(1 / 166)
Explanation	0.077	(13/ 169)	0.078	(13/ 166)
Req_evidence	0	(0/ 49)	0	(0 / 166)
Justification	0.064	(3/ 47)	0.018	(3 / 166)

The consensus relation r2 corresponds to *Agreement* or *Disagreement*. We calculated the probability of the bigram (r1, r2) to see the probability that *Agreement* would come after the *Evidence*. We considered the following two possibilities: when r2 is *Agreement* (*Disagreement*), while r1 is *Evidence* and when r2 is *Agreement* (*Disagreement*), while r1 is any other rhetorical relation. We compared ratios of appearing of *Agreement* and *Disagreement* in evidenced and non-evidenced pairs. The results of the Evidence-based analysis indicated only partial validity of our assumption about *Evidence* being the first relation followed by *Agreement*. Both sequence-based and evidence-based types of analysis only partially confirmed our assumptions.

5 Language Features

We next made another assumption, that language used in discussions has an impact on consensus building. We decided to analyse word unigrams, bigrams and trigrams in different types of statements. In [18] they demonstrated that there were

characteristic words for successful and unsuccessful negotiations called 'indicative words'. We made an attempt to make similar analysis for our collection of discussions from Wikipedia annotated with rhetorical relations.

Our text collection consisted of 320 files of Wikipedia discussion pages, some of them quite long, some rather short. The longest had more than 100 elementary segments; some short ones had just an exchange of two statements. Total number of word tokens was 148948 and number of word types was 11545. As it has already been mentioned statements were considered elementary segments and were annotated with rhetorical relations. It should be added that not every segment was annotated; some statements were left without annotation.

In [18] analysis of negotiations were based on the final result: success or failure of the negotiation; thus all discussion was considered as successful or unsuccessful. In our dialogue there was no final result; we concentrated on each statement as one unit with its rhetorical relation. Firstly, we made frequency dictionaries of words, word bigrams and word trigrams for all statements annotated with the same rhetorical relations. Quick analysis of these dictionaries revealed 'indicative words' for the relations. For example, Disagreement is indicated with the higher rate of negations 'not', 'i don't', 'there is no', 'it is not', etc. Agreement on the contrary, had clear indicators: 'I agree with', 'have to agree'. However, not all relation could be detected so easily; for example, Justification, Explanation, Suggestion had less specific words and much more content words referring to the discussed topic. As 'indicative words' for these relations could be mentioned:

Justification – adverbs 'reasonably', 'rather', 'as well';
Explanation – verbs 'want to', 'could be', 'I feel';
Suggestion – 'I think', 'should be', 'we should'.

We selected all relations pairs r1, r2, where r2 is Agreement or Disagreement and made frequency dictionaries for the texts of first relations which preceded Agreement or Disagreement respectively. Thereby we formed files with all words for the statements which were marked as, for example, Suggestion and preceded statements marked as Agreement. We created unigram, bigram and trigram frequency dictionaries for these statements. The next step was comparison of words for one type of statements which preceded Agreement and Disagreement respectively in order to reveal which words are indicative for the following agreement. In Table 4 some of the most frequent pairs of relations are presented, their indicative words and some comments are added.

In general, we observed that bigrams and trigrams of words which are indicative for agreement do not depend on relation. For all relations we investigated, specific features for Agreement are gentle, polite phrases. Also, to our surprise, pronouns have the great impact on following agreement: 'we' is good indicator of agreement, while 'you' indicate opposition, especially in phrases 'you have' and 'you should'. We did not find verbs to be indicative words. Adverbs also have less impact on the result.

Table 4. Some of frequent pairs of rhetorical relations, their indicative words and comments.

Relation bigram		Indicative words	Comments
r_1	r_2		
Suggestion	Disagreement	highly, quite, rather, reason is quite, should be, would be, better to	suggestions are more categorical and are formulated as from superior to inferior which provoke negation
Evidence	Agreement	we, if, a few, a certain, for the purposes, deem that, can cite some authority	less indicative words, more text about the topic, the language is more concrete and more gentle
Evidence	Disagreement	you due to, you need a, you will need, you'd have to	an aggressive language with many combinations of 'you have', 'you should', etc.

6   Conclusion

In the paper we present some results on the analysis of the relationship between rhetorical structure of the discourse and consensus building. We aimed to find structures of argumentative discourse that lead to agreement. We analysed a collection of web–discussions containing 1764 statements with the total number of 506 participants and 918 rhetorical relations connecting the statements. We applied two types of statistical analysis sequence-based and Evidence-based. The results showed only partial consistency with our initial assumptions.

We also made an investigation of language used in discussions and its influence on the discussion outcome. The investigation of word unigrams, bigrams and trigrams showed that specific features of language which led to *Agreement* or *Disagreement* were similar indifferent which type of rhetorical relation preceded *Agreement* or *Disagreement* respectively. Actually, investigation of discourse structure and language for different types of relations should be a more extensive study. One of the most natural extensions of the study of language in discussion is more sophisticated statistical method application but our collection of discussions is comparatively small and data is rather sparse. Thus, we leave this study for the future when we obtain more annotated data. It is also good to mention that the results of such a study could be used for consensus facilitating function design in an argumentation support system.

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