Towards Using Logical Reasoning for Assessing the Structure and State of a Human Debate

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***Abstract*—Supporting a human debate by logical reasoning facilities is a long-term research goal. Support comprises evidence about argumentative accuracy, detection of inconsistencies, and exposition of acceptable policy positions. This paper elaborates the role and embedding of argumentative utterances, through the use of linguistic tools, which address various aspects of the semantics of natural language. In addition, long-term issues, such as uncovering parts of the semantic content of arguments and its use for reasoning purposes are discussed.**

Keywords–Discourse parser; logical entailment; argumentation graph; argumentation framework.

I. INTRODUCTION

A major goal in the field of computational models for natural argument is to make logical reasoning capabilities accessible for discussions, ultimately in the course of incrementally developing human debates. This issue appears to be notoriously difficult, which is also reflected by some sort of a partition of the research area between natural language approaches and logical models of argumentation, based on non-monotonic reasoning [2], with extremely few connections.

An exception is the approach by Wyner and his colleagues [15], who attempt to interpret a human debate in terms of arguments in favor or disfavor of the issue at stake or some intermediate argument. This way, contributions to the debate can be converted into an *Argumentation Graph*, which is the basic logical structure for computing the state of sets of arguments. The functionality provided by logical reasoning can be exploited — prominently by exposing sets of acceptable, consistent arguments that represent reasonable policy positions of some party — this is an extremely valuable documentation of the state of a debate. Nevertheless, the mapping from natural language statements onto logical assertions is made on a rather superficial level: the proper natural language text is not analyzed below the level of arguments, and the method also relies on the assessment of the contributors to the debate — they have to state which previous argument their new one relates to, and whether it attacks or supports it. We examine a number of methods to expand and strengthen this approach, as an extension to our elaborations in [4].

This paper is organized as follows. In section 2, we analyze shortcomings of human assignments of arguments and resulting deficits. In section 3, we discuss potential examinations addressing these deficit, supported by linguistic tools. In section 4, we address the long-term issue of transferring portions of contents in the debate to the logical level. In section 5, we discuss future developments.

II. SOURCES FOR SUPPORT BY LOGICAL REASONING

The method by [15] relies on rather accurate assessments of participants in a debate with regard to the role of arguments raised and their relation to the embedding debate. However, when a human debate evolves in a typical manner, people sometimes raise their arguments in a sloppy fashion. This is not surprising, since the majority of them are far from being well-trained attorneys. In contrast to the human perspective of communication, percolating the inaccuracy of arguments to the logical level is likely to limit the usefulness of a logical support system, which itself exhibits strong rigor. Hence, it is quite advisable to perceive arguments in the most accurate form. As already observed and discussed in [4], arguments may be inaccurate in at least the following ways:

1) A contribution to the debate may be not a proper argument, in the sense that this statement does not attack or support an argument raised before, but it may be associated with such an argument in another way, typically by expanding its description.
2) An argument may be indicated by a debater as attacker or supporter of some other argument, but this relation may be better conceived as an indirect one, since the argument directly attacks resp. supports another argument related to the one indicated.
3) Arguments may have logical flaws of various kind, ranging from logical inconsistencies (typically in the embedding context) to subtle domain-specific ones.

The first deficit may lead to multiple representations of what is essentially the same argument — this may lead to temporary inconsistencies and repeated attacks in the subsequent debate. A similar overhead in reasoning may result from the second deficit. Issues associated with the third deficit may be various. Therefore, it is important to obtain a representation of the debate as accurate as possible, to exploit the functionality of logical tools attached. To envision this goal, we aim at computing the role and relations of arguments automatically, which a participant in a debate can accept or overrule.

III. USE OF LINGUISTIC TOOLS TO SUPPORT ASSESSING THE STRUCTURE AND STATE OF A HUMAN DEBATE

In order to address potential deficits of human assessment regarding position and role of an argument we envision a linguistic analysis of the arguments raised, resulting in evidence on the level of discourse. Two things are of interest:

1) the attachment point for a newly raised argument

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1) Every householder should pay tax for the garbage which the householder throws away.
2) No householder should pay tax for the garbage which the householder throws away.
3) Paying tax for garbage increases recycling.
4) Recycling more is good.
5) Paying tax for garbage is unfair.
6) Every householder should be charged equally.
7) Every householder who takes benefits does not recycle.
8) Every householder who does not take benefits pays for every householder who does take benefits.
9) Professor Resicke says that recycling reduces the need for new garbage dumps.
10) A reduction of the need for new garbage dumps is good.
11) Professor Resicke is not objective.
12) Professor Resicke owns a recycling company.
13) A person who owns a recycling company earns money from recycling.
14) Supermarkets create garbage.
15) Supermarkets should pay tax.
16) Supermarkets pass the taxes for the garbage to the consumer.

Figure 1. Human debate as used by Wyner and his colleagues [15].

2) its argumentative role, *attack* or *support*, the fundamental links in an *Argumentation Framework*, or a further description of a previously raised argument.

Two linguistic tools can contribute to this purpose: (1) a discourse parser and (2) a textual entailment component. In both of these, analysis of semantics of natural language is incorporated to achieve the intended functionality.

A discourse parser can check for the rhetorical role of arguments and the relations between them, essentially operationalizing *Rhetorical Structure Theory* [5]. Thereby, the richness of the rhetorical relations in ordinary texts is not of primary interest for our purposes, in view of the limited set of argumentative relations, since only a few rhetorical relations give highly relevant indications. For instance, some semantically strong relations, such as *contrast* and *explanation*, typically cooccur with *attack* and *support*, respectively.

A textual entailment component can check for consistency or possible inconsistency. In particular, a high degree of consistency — assuming the component yields results associated with probabilities - is hardly compatible with an *attack* relation. The reverse direction — inferring textual entailment on the basis of argumentative relations — is possible in some cases. An *attack* relation implies contradiction, but only specific instances of a *support* relation constitute entailment. All these inferences, however, are defeasible on principled grounds: an argumentative relation may be challenged by an *undercutting defeater* [9], which attacks the argumentative relation itself rather than the argument attacking or supporting another one.

At the present state of the art, unfortunately, neither discourse parsers nor textual entailment components are very strong assistants, they give some indications only. Discourse parsers are generally reasonable on structural issues — stating direct or indirect relations between assertions, but they are less accurate on ontological grounds, that is, inferring rhetorical relations. This is mainly because statements raised in the course of a debate, unlike continuous text, are poor in terms of the use of discourse markers. Consequently, most relations are hypothesized as *elaborations*, while the stronger relations that in fact hold between the arguments are not recognized.

For analyzing the following examples, we refer to the web versions of the discourse parser developed at Nanyang Technological University [11] and of AllenNLP's textual entailment tool [12]. We refer to the running example Wyner and his colleagues often have used (see Figure 1).

The ultimate goal is to incrementally build an *Argumentation Graph*, starting from the point of debate — "Every householder should pay tax for the garbage which the householder throws away." and its opposite — 1) and 2) in Figure 1. We do not have a systematic procedure for this purpose yet; in particular, there are too many options for attachment points when the number of arguments grows. Instead, we illustrate contributions of the linguistic tools to the analysis of a few examples, including some controversial interpretations that have been discussed in previous work.

Recognizing the conflation of two statements — one elaborating the other — into a single argument can be supported by checking their rhetorical relation and the degree of entailment holding between them. For example, "Recycling more is good" 4) in Figure 1), indicated as a *support* for "Paying tax for garbage increases recycling" 3) is assessed as an *elaboration* by the discourse parser. Moreover, the textual entailment tool gives 66 percent entailment for this pair of statements, and only 1 percent contradiction, which are quite strong values.

Looking at another example, an *explanation* relation is predicted by the discourse parser, stating that "Every householder who takes benefits does not recycle" (7) in Figure 1) explains "Every householder who does not take benefits pays for every householder who does take benefits" 8); this is a strong indication that these arguments should be nested rather than in parallel, as assessed by the human in the debate [16].

Textual entailment gives a weak though rather consistent evidence about the polarity of an argument, whether it is an attack or a support — this may be helpful in case a user slips in the use of the interface. For example, according to the textual entailment tool, "Paying tax for garbage increases recycling." 3) (Figure 1) is entailed by "Every householder should pay tax for the garbage which the householder throws away" 1), at a 53 percent level, but it is assessed to be a contradiction at a 76 percent level to "No householder should pay tax ..." 2). By the way, the weaker assertion "Not every householder should pay tax for the garbage which the householder throws away" is rather undecided, it yields a contradiction at a 36 percent level, and entailment at a 26 percent level.

IV. Making Natural Language Content Accessible to Logical Reasoning

The proper natural language content of arguments is not transferred to the logical level, since arguments in an *Argumentation Graph* appear as atomic units. This abstraction prohibits reasoning about portions of natural language statements raised as an argument, within individual arguments, and across several ones. A more detailed logical model would enable testing whether a natural language statement is consistent in itself,

and whether stating an *attack* or a *support* relation between two arguments is acceptable, that is, this does not imply a contradiction. A richer representation of arguments can also make more advanced versions of *Argumentation Frameworks* accessible — the basic version only deals with *attacks* — these may include structured arguments [8] and priorities [10] or different strengths [1] associated with arguments.

In order to make at least portions of natural language content accessible to logical reasoning, proper linguistic analysis has to be carried out, so that semantic issues have to be dealt with explicitly and not only within the scope of the discourse parser and the textual entailment tool. In [16] this task has elaborated for restricted English, but the results are not used for logical reasoning purposes.

In order to go beyond restricted English, the semantic representation needs to undergo some sort of a normative process, to cater for paraphrases and varieties of linguistic forms. An appropriate strategy appears to be breaking down representations into atomic relations, and mapping these relations onto the repertoire stored in a knowledge representation repository with a preferably large set of ontological definitions, the biggest one being OpenCyc [6], used as in [7]. Defining this uniformity-emphasizing mapping process constitutes a challenge involving semantic issues. In dependency of the argumentative statements in a specific debate, not all of them need to be broken down into atomic relations; some composite ones often reoccurring may be maintained.

A case for such composite relations can be made when recognition of *Argumentation Schemes* [13][14] within a debate is attempted, *Appeal to Expert Opinion* being such as a scheme. The arguments 11) to 13) in Figure 1 instantiate a part of this scheme, in terms of a *critical question* ("Professor Resicke is not objective.") 11), followed by the associated justification ("Professor Resicke owns a recycling company." 12) and "A person who owns a recycling company earns money from recycling." 13)). Treating "Owning a recycling company" as a single predicate is enough abstraction to recognize the presence of the *Argumentation Scheme*.

V. Conclusion and Future Work

In this paper, we have discussed methods for assessing the structure and state of a human debate. This is done by consulting linguistic tools to make structure and content of natural language arguments represented better and thus more accurately accessible to logical reasoning facilities.

First steps towards operationalizing the concepts exposed in the paper are installation of the tools we have referred to via their demo versions, in the hope of getting more accurate results - later versions are likely to better capture the semantics of rhetorical relations, by incorporating results of research, such as [3]. In addition, categorization of statements (such as, "...is good/bad") in combination of selected uses of linguistic tools can be defined to check/improve the argumentation structure incrementally built. Most importantly, a systematic procedure for building an *Argumentation Graph* needs to be developed. Thereby, focusing on suitable attachment points is important (a statement about supermarkets is likely to expand a previously raised argument about supermarkets), as well as a metric assessing the contextually obtained results of linguistic tools. Moreover, analyzing focused portions of the argumentative discourse may be suitable, taking into account the difference between a multi-party debate and a monological presentation, which is what discourse parsers expect.

A long term perspective lies in examining the natural language content of arguments, complementing the atomic perspective of logical reasoning about acceptability state of sets of arguments by internal structures that enable checking consistency - a first step towards addressing plausibility.

Limitations even in advanced versions of this approach will be reasoning functionality which requires world knowledge more detailed than what has been made accessible to logical reasoning, which virtually includes all background knowledge; limited elaborations for specific domains may be an exception. Moreover, irony is unlikely to be treated automatically in a useful manner; it has not been addressed in the argumentation context so far.

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