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Abstract: Computer tools are increasingly used to support the analysis of argumentative texts. Generic support for argumentation analysis is helpful, but catering to the requirements of specific theoretical approaches has additional advantages. Although the pragma-dialectical method of analyzing argumentative texts is widely used, no dedicated computational support tools exist. An outline is presented for the development of such tools, that starts with the formal approximation of the pragma-dialectical ideal model of a critical discussion.

Keywords: analysis, computational argumentation theory, computer support, critical discussion, formalization, pragma-dialectics, reconstruction

1. Introduction

The prospect of improving argumentative practice has been one of the main catalysts of modern argumentation theory. It was clear to Perelman (Perelman and Olbrechts-Tyteca 1958) and Toulmin (1958) that the formal study of logic did not provide society with the best means to understand and improve reasoning and argumentation in practice – a sentiment shared to some extent by the Informal Logicians (e.g. Johnson and Blair 1977) and the Pragma-Dialecticians (van Eemeren 1978; van Eemeren and Grootendorst 1982) that shaped the modern field of argumentation studies.

By studying how people use language and reason to persuade each other, and by identifying the norms that govern this process, argumentative practice can be improved in at least two ways. On the one hand, people can be educated about reasonable ways of arguing, about fallacies, and about rhetorical strategies to improve their individual skills (e.g., van Eemeren et al. 2005; van Eemeren, Garssen and Rietstap 2014). On the other hand, the various kinds of designs of the institutional contexts in which argumentation occurs can be improved (van Eemeren, Grootendorst, Jackson and Jacobs 1993; Jackson 2015). By providing people with advice and instruction or with better tools, their argumentative skills and behaviour may be improved.

Increasingly, the tools and environments that shape argumentative reality are digital, computer-based, and online. For example, any written argumentative discourse on the Internet is implicitly guided and constrained by the opportunities that the particular forum, blog, or social network website offers to its users. The guides and constraints on these online environments may promote or may hamper reasonable argumentation (cf. Lewinski 2010). Aside from shaping online discourse, digital tools to support argumentation and reasoning are making their way into the workflow of professional experts, such as doctors making diagnoses, lawyers preparing their cases, and marketers choosing their advertising strategies. The engineering of these kinds of digital tools to support the practice of argumentation and reasoning requires expertise from several fields, most notably from argumentation theory or decision-making theory and computer

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science. Limiting the scope to argumentative practice, this leads to a multi-disciplinary research field concerned with computational argumentation theory. In Section 2, I will present a selective overview of this field.

Aside from tools to support professional experts in their argumentative tasks, computer software can also be used to aid argumentation scholars. The use of computer support makes some academic tasks easier, such as the drawing of argumentation structures. Additionally, it opens up previously unavailable research opportunities, such as identifying argumentative elements in large text corpora in a short period of time. An additional advantage of the use of computer support is that it standardises the output of, for example, the analysis of argumentation. The software guides the user through a unified set of analytical steps, towards a uniform output pattern, thereby promoting objectivity in the analysis. The uniformity makes it easier to track the analytical steps that were taken and to compare analyses.

Because computational support tools implement specific models of argumentation, they are not theory-neutral and mostly not compatible with other approaches. So far, no computer support has been built specifically aimed at argumentative tasks (production, analysis, evaluation) based on the pragma-dialectical theory of argumentation. This absence is surprising, because the pragma-dialectical theory is one of the central approaches in the field of argumentation studies. The approach constitutes an elaborate research program with components covering the philosophical, theoretical, analytical, empirical and practical components of argumentation studies (van Eemeren et al. 2014, pp. 517-613). On the basis of a philosophical ideal (a critical conception of reasonableness), a theoretical ideal model of a critical discussion is devised, which is subsequently used as a heuristic in the study of argumentative practice (van Eemeren 2010). Because of the normative basis of the ideal model and the fact that it involves all discussion stages relevant to the resolution of a difference of opinion, the model can be used in the evaluation of (informal) fallacies. Furthermore, the conventional validity of the model (the degree to which ordinary language users agree with the implemented norms) has been tested empirically by van Eemeren, Garssen and Meuffels (2009).

The ideal model forms the basis for the pragma-dialectical method of analysing argumentative texts (van Eemeren and Grootendorst 1992; van Eemeren 2015b). This analytical method is arguably one of the most complete and well-established analytical methods in argumentation theory. It is used (and has been refined) for more than thirty-five years by research groups and argumentation scholars around the world. In Section 3, I will look into the possibilities for computational tools to support the pragma-dialectical analysis of argumentation.

One reason for the current absence of such computational support tools is that the pragma-dialectical model is presented in informal terms, while the field of computer science is inherently formal in its orientation. Furthermore, it is not immediately clear how the pragma-dialectical theory in total is to be approached when looking for formalisation opportunities, which is why the absence of insights from pragma-dialectical theorising in the field of computational argumentation theory is not so surprising. Bridging the conceptual gap between the inherently formal computer science and the informally presented pragma-dialectical theory is a precondition for the development of computational tools to support pragma-dialectical research or argumentation theory. In Section 4, I will look into an approach to the formalisation of the pragma-dialectical discussion model in preparation of computational application.

2. Computer support for argumentative tasks

The development of computational tools to support argumentative practice (of both ordinary language users and argumentation scholars) is part of the multi-disciplinary field of computational argumentation theory. The research in this field combines insights and techniques from argumentation theory with those from computer science. Although the term 'computational argumentation theory' may point at a primarily theoretical focus, it should rather be understood to cover theoretical consideration as well as practical application and engineering. From the perspective of computer science, Simon Parsons (2016), in his keynote address at the first European Conference on Argumentation, emphasised the efficacy of insight about argumentation for solving computational issues. Similarly, from the perspective of argumentation theory, Frans van Eemeren (2015a) reiterated the importance of computerisation in his keynote address opening the eighth conference of the International Society for the Study of Argumentation.

As a result of combining two disciplinary backgrounds, most contributions in computational argumentation theory can be characterised as falling into one of two categories: argumentative means to address computational problems, or computational means to address argumentative problems. I will provide a selective overview of the state of the field from the perspective of argumentation theory. Concise overviews of the different strands of scholarship on the intersection of argumentation theory and computer science are provided in, for example, the volume *Argumentation in Artificial Intelligence* edited by Rahwan and Simari (2009), and the chapter 'Argumentation and Artificial Intelligence' in the *Handbook of Argumentation Theory* (van Eemeren et al. 2014, pp. 615-675).

2.1. Argumentative means for computational tasks

The first category of contributions, those using argumentative insights to solve problems in computer science, can in turn be subdivided into two broad themes (although these two themes are certainly not fully distinct and there is overlap between the two). The first theme concerns the use of argumentation theoretical insights to provide a foundation for the modelling of defeasible reasoning in Artificial Intelligence. Taking place within one (artificial) agent, this form of 'intra-agent' reasoning should be able to deal with incomplete, possibly inconsistent, and dynamic knowledge bases. Argumentation-based defeasible reasoning has been proposed as an alternative to classical, monotonic logic, which turned out to be ill equipped to deal with the vagueness and mutability of an agent's reasoning.

The use of insight into the argumentative relations of justification and refutation between propositions has proven a useful basis for so-called systems for commonsense reasoning (Prakken and Vreeswijk 2002). The works by Pollock (1987) and Dung (1995) form the most widely used theoretical foundations for this application of argumentative principles to address computational issues. In their work both Pollock and Dung abstract away from the content of premises of arguments and focus mainly on the relations of conflict between premises.[1]

To give material substance to the conflict relations and to reintroduce the importance of support relations, the notion of argument schemes has been employed. Argument schemes and their accompanying critical questions that can be used to test the acceptability of the inference

[1] This extreme form of abstraction is not necessarily problematic. Rather than serving as a heuristic framework to analyse argumentative discourse, the 'arguments' are used in a mathematical way as constructs to perform automated reasoning with.

have been widely studied in argumentation theory (e.g. Hastings 1963; van Eemeren, Grootendorst and Kruiger 1978, p. 20; van Eemeren and Grootendorst 1992; Kienpointner 1992; Walton 1996; Garssen 2002). Especially Walton's work on argument schemes has found uptake within the argumentation-oriented part of computer science (see also Walton, Reed and Macagno 2008, pp. 393-415).

The second theme I distinguish in the use of argumentative insights to address computational issues, is the use of argumentation theory for 'inter-agent' communication in computational multi-agent systems (computer systems in which several agents interact and solve problems in a distributed way). Insights about human argumentative behaviour are employed to develop communication protocols that allow artificial agents to interact and reach a mutual alignment of beliefs and plans. Mimicking natural persuasion and deliberation, the agents in computational multi-agent systems can be designed to advance arguments in defence of their own point of view or against that of other agents, thereby attempting to come to a joint plan or belief.

The theoretical foundation for these developments is mainly found in the dialectical studies of argumentation (e.g. Hamblin 1970; Rescher 1977; Barth and Krabbe 1982). Most influential in this respect is Walton and Krabbe's (1995) book *Commitment in Dialogue*. Their categorisation of dialogue types has led to a series of computational implementations of dialogue protocols for persuasion (Prakken 2009), deliberation (McBurney, Hitchcock and Parsons 2007), and negotiation (Amgoud, Maudet and Parsons 2000), among others. The dialogue protocols offer a set of rules that allows agents to reach some interactive goal through communication – for example to determine a plan of action, to distribute resources, or to accumulate knowledge.

2.2. Computational means for argumentative tasks

The second category of contributions to computational argumentation theory may be characterised as using computational tools to support argumentative tasks. These support tools can be aimed at ordinary language users and professional experts, but also at argumentation scholars. Especially in the latter case, the use of computational methods for studies in the humanities can be considered part of the Digital Humanities (see Schreibman, Siemens and Unsworth 2004). The study of argumentation is generally concerned with three 'argumentative tasks': the production, the analysis, and the evaluation of argumentation. Most of the existing computational support tools can be classified along the lines of these three argumentative tasks, although in some cases the distinction cannot be made so strictly and a tool may be relevant to several tasks.

Computational tools supporting the production of argumentation are mostly focused on the structuring (the classical notion of *dispositio*) of the user's argumentation instead of on the way the argumentation is presented (the classical notion of *elocutio*). Using software to visually layout their case can help users to better understand the relations between standpoints, arguments and counter-arguments (for example by using van Gelder's (2007) software Rationale). The diagramming of argumentation structures is also a main function of computational tools aimed at the analysis of argumentation. Because an overview of the argumentation structure is a crucial outcome of an argumentative analysis, this is not surprising.

There are various computer programs that let users diagram the argumentation structure of reconstructed or analysed texts (for example Araucaria (Reed and Rowe 2004) and its successor OVA).[2] These programs are designed to support human analysts in reconstructing argumentative texts. An additional advantage of using software to diagram the argumentation structure of analysed texts is the possibility to archive it in an online repository (such as the AIFdb (Lawrence, Bex, Reed and Snaith 2012)).

The next step in the development of software for argumentation analysis is the automation of the reconstruction itself. This is the objective of 'argument mining' (e.g., Budzynska et al. 2014; Lippi and Torroni 2015). On the one hand, the scale at which argumentative elements can be identified in text corpora is greatly enlarged through argument mining techniques, because a computer can do this task much quicker than a human analyst. The quality of the automated reconstruction, on the other hand, is not at the level of that of a trained human analyst – not yet.

On the basis of the analysis of an argumentative text, the argumentation can be evaluated. The evaluative task can be understood as deciding on the reasonableness or fallaciousness of the argumentation or as deciding on the acceptability of an outcome or conclusion of an argumentative process. Most of the computational tools to support the evaluation are focused exclusively on the second interpretation of 'evaluation'. To my knowledge there are no examples of computational tools that cover a wide range of fallacies, in particular none that cover the (so-called) informal fallacies (i.e. the non-inferential fallacies). A reason for this may be the lack of a theory of fallacies (beyond the formal or logical fallacies) that is ready to be implemented in a computational system – another reason to computationally develop the pragma-dialectical theory (see sections 3 and 4), which offers a concise explanation of fallacies (van Eemeren and Grootendorst 1992, pp. 93-217).

As Walton (2016) recently pointed out, there are several studies on the topic of the computational determining of preferred or acceptable outcomes or conclusions of argumentation or reasoning. Software for diagramming the reasoning that underlies argumentative discourse (or any other reasoning for that matter), and decision-making tools based on, for example, Dung's abstract argumentation frameworks, often let users evaluate the structure of the reasoning (e.g. TOAST (Snaith and Reed 2012)). By first assigning values to certain parts of the structured reasoning, evaluation software can subsequently calculate the preferred or acceptable conclusion by weighing the accepted arguments for and against it (see Walton 2016).

Some of the computational tools aimed at the support of argumentative practice are designed with a particular practical context of application in mind. The software can then be catered to the specific characteristics of argumentative practice within the institutionalised context at hand (see van Eemeren 2010, pp. 129-162). For example, in the educational domain, computer programs are used to teach argumentative skills (see, e.g., Kirchner, Buckingham Shum and Carr 2003, pp. 25-47). Especially in collaborative online settings, argumentation theoretical insights are used in two ways (see Scheuer, Loll, Pinkwart and McLaren 2010). First, in 'learning to argue', the software supports the students' apprehension of argumentative skills. Second, in 'arguing to learn', the idea is that forcing students to engage in argumentative discussions about certain topics through an online platform, increases their apprehension of the topic. As a case in point, Belvedere (Suthers, Weiner, Connelly and Paolucci 1995) is a computer program that supports students in reasoning about a topic, by visualising their arguments pro and con in a structured diagram.

Another domain, which historically has received a lot of attention from argumentation scholars, is legal communication. To support legal practitioners in preparing their case, systems

[2] OVA is available at: http://ova.arg-tech.org.

such as Verheij's (2005) ArguMed and Gordon et al.'s (2007) Carneades can be used to diagram and evaluate argumentation structures. Another example of computer applications for legal argumentation is found in online dispute resolution. By employing knowledge about persuasion dialogue and negotiation, a dispute may be settled before being brought before a judge (e.g., Bellucci, Lodder and Zeleznikow 2004). A final example is the medical domain. To improve the distribution of donor organs among different hospitals with often conflicting interests, argumentation is used as an inspiration for decision-making software (e.g., Tolchinsky, Cortés and Grecu 2008). In health communication, computer systems are designed to help medical experts explain difficult topics that require medical expertise to layman patients (Green, Dwight, Navoraphan and Stadler 2011).

3. Pragma-dialectical argumentation analysis and computer support

To illustrate how computational tools can support the analysis of argumentation using the pragma-dialectical method (van Eemeren and Grootendorst 1992), the analytical method will be presented in a procedural manner.[3] This procedural perspective on the analysis is admittedly artificial. That is, the explanation given here should not be taken as a representative description of what analysts do when they analyse a text. More often than not – and this especially applies to experienced analysts – instead of following the clinical procedure presented here, analysts will go back and forth through the text and the analytical steps; sometimes performing several operations at once, sometimes skipping steps, etc. Although this 'organic' approach works for analysts that can rely on their experience and their natural feeling for language and the communicative situation, by decomposing the analytical process into its constitutive steps, it becomes clearer where computer support can be usefully applied.

The pragma-dialectical method of analysis is comprised of two sub-tasks: the reconstruction sub-task and the abstraction sub-task. In the reconstruction sub-task, the parts of the original text that are argumentatively relevant are identified by using the ideal model of critical discussion as a heuristic (van Eemeren and Grootendorst 1992, p. 36). In this discussion model an ideal procedure is proposed for the reasonable resolution of differences of opinion (van Eemeren and Grootendorst 2004, pp. 42-68). By using the ideal model as a heuristic, the analyst reconstructs the original text as if it were a discussion aimed at the resolution of a difference of opinion. To arrive at this reconstruction in terms of the ideal model, the analyst applies four transformations – deletion, addition, substitution and permutation (van Eemeren and Grootendorst 1990; van Eemeren, Grootendorst, Jackson and Jacobs 1993, pp. 61-62) – which bring the original text analytically in line with the ideal model.

Next, as part of the abstraction sub-task of the pragma-dialectical method of analysis, an analytic overview is constructed on the basis of the outcome of the reconstruction sub-task (van Eemeren, Grootendorst and Kruiger 1983, p. 290). The analytic overview contains indications of everything that is analytically relevant in the text from an argumentative perspective: the standpoint(s) at issue, the distribution of the discussion roles, the material and procedural starting points, the argumentation structure and the argument schemes (van Eemeren and Grootendorst

[3] The procedure presented here characterises the 'standard' pragma-dialectical analysis. This means that the rhetorical dimension of argumentative discourse, which deals with arguers' strategic manoeuvring in a conventionalised communicative context, is not taken into account. For explanations of the extension of the pragma-dialectical analysis focused on these matters, see van Eemeren (2010; 2015b) and van Poppel (2015). An early algorithmic procedure for standard pragma-dialectical analysis is proposed by Skolnik (1996).

2004, p. 118), as well as the outcome of the discussion (van Eemeren 2010, p. 12). The analytic overview forms the basis for the subsequent argumentative evaluation of the text (which was alluded to in the previous section, but which is not discussed further in the present paper).

In a more detailed explanation of the two sub-tasks of the pragma-dialectical analytical method (Subsection 3.1 and 3.2), I will indicate where dedicated computational tools would fit in. In the explanation, the short (artificial) dialogue fragment in Example 1 will be used as the text that is to be analysed. Intuitively it will be obvious that Paul makes a contentious statement, about which Olga expresses some doubt, which leads to Paul defending his statement with an argument. Example 1 is kept simple on purpose to explain the analytical procedure that also produces a theoretically justifiable analysis of texts that are intuitively less clear.

Example 1:

(1) Paul: I think it will start raining soon.
(2) Olga: Why do you think so?
(3) Paul: Because the clouds keep getting darker.
(4) Olga: Ah, I see.

3.1 The reconstruction sub-task of a pragma-dialectical analysis

As part of the first sub-task of the analysis, the text (in our present case, Example 1) is reconstructed in terms of the ideal model of a critical discussion. Because the ideal model of a critical discussion is more complex than is needed for the current exposition, I will make use of a very simple dialectical model, which I shall call DISC. The DISC model is only introduced to clarify the procedural exposition of the analytical method without getting lost in details. It explicitly does not serve to elucidate, for example, the dynamics of actual argumentative discussions.

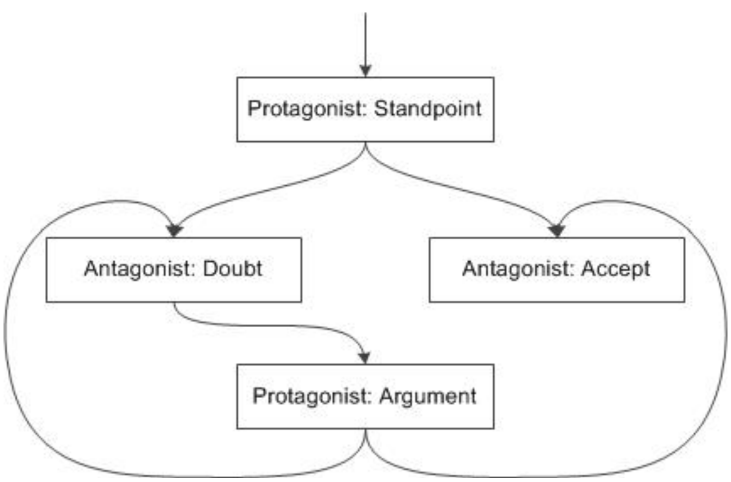

Figure 1: The sequential structure of DISC.

Instead of giving a full (formal) definition of DISC, I will introduce it informally. In DISC there are two discussants: the protagonist and the antagonist. A dialogue of DISC is started when the protagonist puts forward a standpoint, and then progresses with the discussants taking turns to make moves. The antagonist has two options after any of the protagonist's moves: to accept it or not to accept it (by casting doubt). After his opening move, the protagonist can only put forward arguments in response to the antagonist's possible doubt. Dialogues of DISC terminate when the antagonist accepts one of the protagonist's moves. The sequential structure of this model can be visualised as the graph in Figure 1, in which the players and moves are represented as text boxes (the nodes of the graph) and the possible sequences of moves are indicated by the arrows (the edges of the graph).

Whereas in a pragma-dialectical analysis a text is reconstructed in terms of the ideal model of critical discussion, in the current example the text is reconstructed in terms of DISC. Regardless of the model used, the process is the same (albeit less elaborate in the case of DISC, due to the simplicity of the model). Four analytical transformations (van Eemeren and Grootendorst 1990; van Eemeren, Grootendorst, Jackson and Jacobs 1993, pp. 61-62) are used to cast the dialogue of Example 1 between Paul and Olga in the mould provided by the DISC model. By applying the analytical transformations of substitution, permutation, addition, and deletion the example text is reconstructed as if it were a dialogue of DISC. The contributions by Paul and Olga in Example 1 are reconstructed as moves in DISC. In texts that are more complex than Example 1, a systematic use of the pragma-dialectical interpretative and reconstructive tools is necessary. Among these tools are insights from speech act theory (van Eemeren and Grootendorst 1984, pp. 19-46) integrated with a Gricean (1975) perspective on communication (van Eemeren and Grootendorst 1992, pp. 49-59), insight into the possible function of argumentative indicators (van Eemeren, Houtlosser and Snoeck Henkemans 2007), and the typology of argument schemes (van Eemeren and Grootendorst 1992, pp. 94-102; Garssen 2002)). The dialogue of Example 1, on the other hand, is constructed in such a way that the structure of the text and the indicator words used make reconstruction in terms of the DISC model fairly easy.

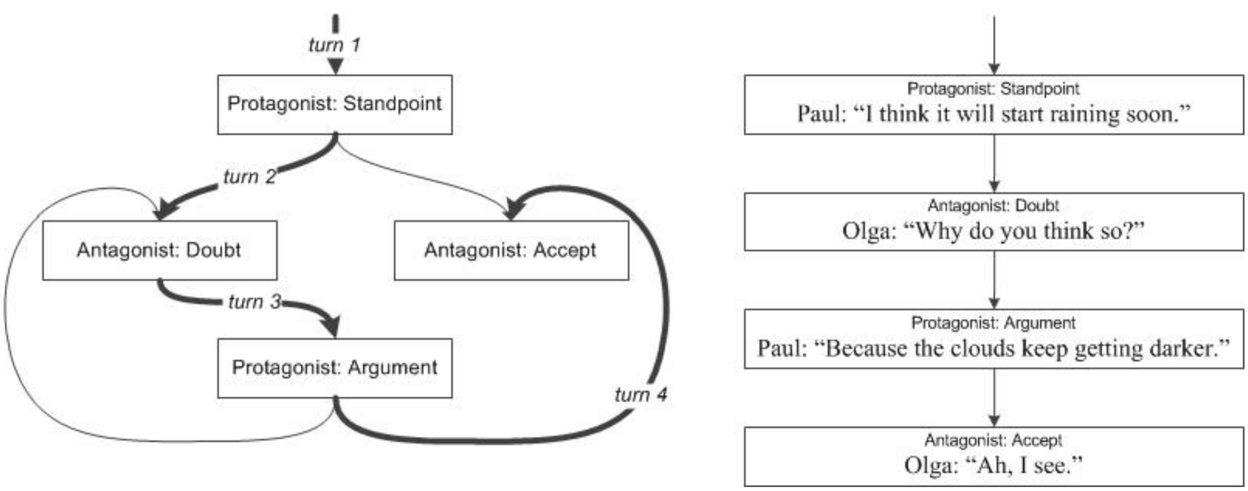

Figure 2: Example dialogue reconstructed in terms of DISC.

There are only four possible moves in DISC onto which the contributions to the dialogue of Example 1 can be mapped. On the basis of Paul's use of the indicator of standpoints "I think that" (see van Eemeren, Houtlosser and Snoeck Henkemans 2007, p. 29), his first move is reconstructed as an instance of 'Standpoint' in DISC. Olga's use of the indicator "Why" (van Eemeren, Houtlosser and Snoeck Henkemans 2007, p. 48) in her response is reconstructed as an expression of 'Doubt' in DISC. Paul's subsequent reason, indicated by "Because" (van Eemeren, Houtlosser and Snoeck Henkemans 2007, p. 166), is reconstructed as an 'Argument' in DISC. Lastly, Olga's admission of acceptance of the standpoint, indicated by "I see" (van Eemeren, Houtlosser and Snoeck Henkemans 2007, p. 230), is reconstructed as an 'Accept'-move in DISC.

This sequence of moves is one of the possible routes through the profile of DISC as shown on the left side of Figure 2. The arrows are labelled with the turn in which that move is selected. The sequence of DISC moves instantiated with the results of the very basic reconstruction of the example dialogue is shown on the right side of Figure 2. Especially when texts are longer, it would be useful if a computer program highlighted the (groups of) words that can be indicative of argumentative moves. Of course not all such indicators are actually reliable, so the analyst should consider the automated highlighting of indicators as one of several interacting reconstructive tools.

3.2. The abstraction sub-task of a pragma-dialectical analysis

Following the reconstruction in terms of the ideal model – DISC in the example, critical discussion in a real pragma-dialectical analysis – the results are collected in the analytic overview. Each of the elements of the analytic overview corresponds to a particular move in the discussion model. In Figure 3, I have indicated how the moves in DISC correspond to three of the elements of the analytic overview.[4] Based on these correspondences, the analytic overview can be abstracted from the reconstructed discussion. Because the content of the analytic overview is fully determined by the reconstruction in terms of the ideal model, the step from reconstruction to analytic overview seems to be very suitable for automation.

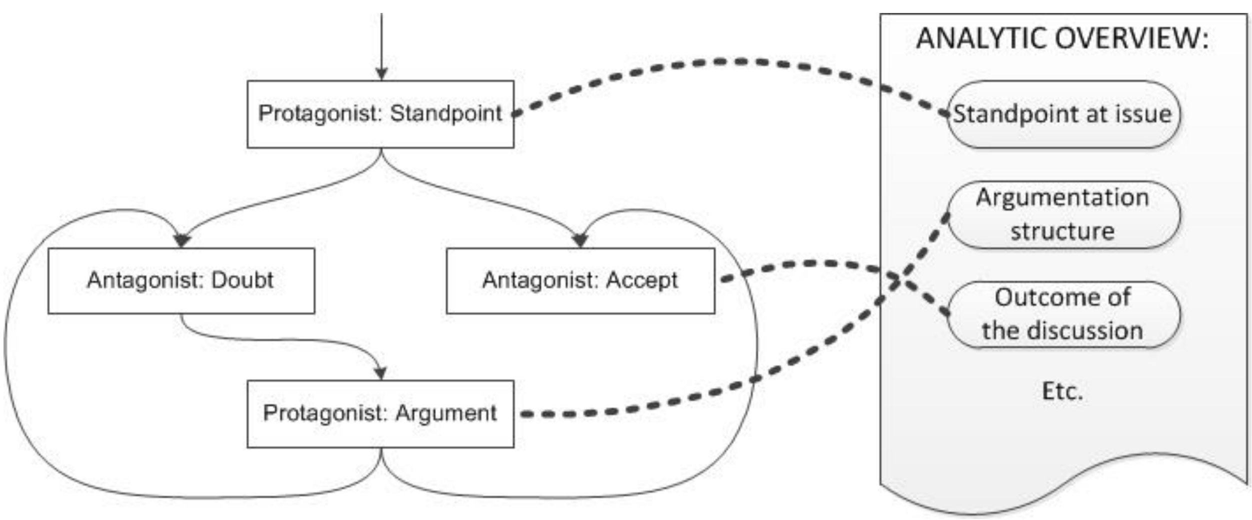

Figure 3: The relation between the discussion model and analytical notions.

Due to the correspondence between the first move as reconstructed in terms of DISC, and the element 'standpoint at issue' in the analytic overview, after the analysis it turns out that the

[4] The analytic overview of the dialogue of Example 1 is only partial, because it is reconstructed in terms of DISC, which is much more restrictive than the ideal model of a critical discussion.

standpoint in Example 1 is ‘it will start raining soon’. Likewise, the outcome that both discussants accept the standpoint is clear from the reconstructed last move of the discussion.

The structure of the argumentation depends on the move “Protagonist: Argument”. This move is used once in turn 3 of the example. If the move were made more than once, the argumentation structure would be subordinatively compound, with every subsequent argument defending the previous. Since only one argument was presented, the argumentation structure is single, as shown in Figure 4.[5]

In section 2, I already mentioned some examples of software that can be used to visualise argumentation structures. However, these programs are not based on a pragma-dialectical interpretation and are therefore lacking in functionality from the perspective of the pragma-dialectical analysis and subsequent evaluation. For example, the treatment of coordinatively compound argumentation is particular to the pragma-dialectical approach (van Eemeren and Grootendorst 1992, pp. 76-82) and not treated in the same way in existing computer systems (e.g., Walton 2016). An additional feature that would be useful is the possibility to translate between the diagrammatic visualisation of the argumentation structure such as in Figure 4, and the traditional pragma-dialectical ‘list notation’ of the same structure:

1 it will start raining soon
1.1 the clouds keep getting darker
(1.1’) (the clouds keep getting darker, therefore it will start raining soon)

For educational purposes, it would be useful if software could be used to compare two argumentation structures in an automated way – much like some word processing software can compare two text files. Because the software enforces a standardised layout, it could compare a student’s reconstructed argumentation structure in an assignment to the one given in the answer guidelines for grading.

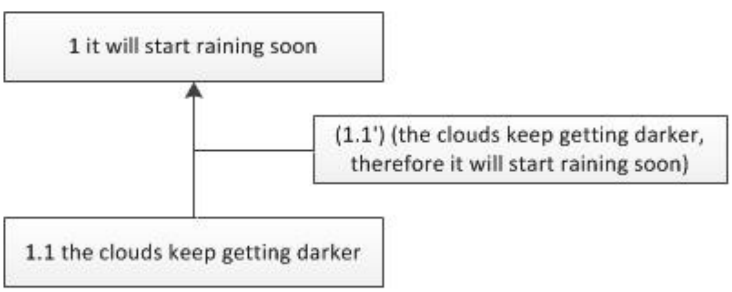

Figure 4: The argumentation structure of Example 1.

After a text is reconstructed and an analytic overview is abstracted, it would be very useful if the analysis were available to others. A good way of archiving and disseminating the analysed texts with the resulting analyses is by using a web-based service (such as the AIFdb mentioned in section 2). Over the past 35 years a lot of pragma-dialectical analyses have been produced, but most of these did not leave the office or computer of the analyst, with the exception of the fragments that were published in articles or books. With a computer tool that

[5] The brackets are used to indicate that this premise of the argumentation was unexpressed in the original text, but was reconstructed (van Eemeren and Grootendorst 1992, pp. 60-72).

allows the archival of pragma-dialectical analyses, these can be made available for educational purposes (to train argumentative or analytical skills) or for academic purposes (for example, to easily test inter-coder reliability).

Both Example 1 and the DISC discussion model were intentionally kept very simple. Therefore, the analytic overview that resulted from the analysis in two sub-tasks is not surprising. The point is that when using a more complex model as a heuristic instrument during the reconstruction sub-task, a method like the one presented here can also be applied to much more complicated texts, leading to overviews that were not immediately available on the basis of intuition alone. The computational tools that were mentioned during the explanation of the analytical method could make it easier to follow the procedure. Especially since the reconstruction of more complex texts, with a more complex model such as the ideal model of a critical discussion, soon leads to a complicated analytical process in which many things need to be kept track of.

The ultimate computational tool would be one that automates the complete analysis. Progress into this direction is made in terms of the aforementioned argument mining, but these computational techniques do not yet deliver analyses of comparable quality to those made by human analysts. In order to build a computer system that fully automates the pragma-dialectical analytical method, computational representations of the text under analysis, of the ideal model, and of the analytic overview are required. In addition, computational implementation of the procedures for the reconstruction sub-task and for the abstraction sub-task of the analysis would be needed. Several technical and theoretical problems still stand in the way of such computerisation of the pragma-dialectical analytical method. One obvious obstacle is natural language processing: engineering computers to understand the meaning of texts in natural language, which is still an open problem in Artificial Intelligence. A second obstacle is the absence of the computational representations I just mentioned, which is what I will turn to in the next section.

4. An outline of the development of pragma-dialectical computer support

4.1. From philosophical ideal to software implementation

Computer software for argumentative tasks, as described in Section 2, is always based on a specific argumentative framework or model. The model gives meaning to the argumentative notions that are used in the software. This is done by applying a computational implementation of the model, which makes it accessible to the computer software. In turn, the computational model implements some formal model of argumentation. The formal model is based on a theoretical model. And, finally, this theoretical model is based on a philosophical ideal. This retrospective path, tracking the heritage of the argumentative notions in dedicated support software, can be used to indicate the steps that still need to be taken in the development of support software for the pragma-dialectical analysis of argumentation.

The pragma-dialectical ideal model of a critical discussion, which is at the basis of the analytical method, is a theoretical model. It is based on a philosophical ideal, implementing a conception of reasonableness that is inspired by critical rationalism (see van Eemeren and Grootendorst 2004, pp. 123-134; Albert 1975). The next step, in the list I presented above, towards software applications is the transition to a formal model. This is necessary because of the inherently formal nature of computer science, where everything has to be defined strictly and unambiguously in the programming language used. For computer programs to function, the systems developed with these programming languages need to adhere to specific preconditions: e.g., there may be no exceptions that are not covered, nor holes or loops, or room for unexpected errors. Therefore, a certain degree of formality is required of argumentation models that are to be used as the basis for computer programs.

4.2. The formal approximation of the pragma-dialectical discussion model

A model can be called ‘formal’ in different senses.[6] The five different senses of ‘formal’ distinguished by Barth and Krabbe (1982, pp. 14-19; Krabbe 1982) form a good starting point for a discussion of the intended sense of formal, when I speak of a formal version of the pragma-dialectical ideal model.[7] The first and last senses Barth and Krabbe distinguish – relating to Platonic forms and non-material systems, respectively – are not the intended senses of ‘formal’ in this regard. The three remaining senses are all relevant. The formal model should contain a rigid definition of the well-formed linguistic expressions and the way in which these can be combined ($formal_2$ in Barth and Krabbe’s taxonomy), should be procedurally regimented ($formal_3$), and *a priori* or normative ($formal_4$). Krabbe and his co-authors (Krabbe and Walton 2011, p. 246; Krabbe 2012, p. 12; van Eemeren et al. 2014, p. 304) have pointed out that the existing pragma-dialectical ideal model is already $formal_3$ and $formal_4$. The objective in the *formal approximation* of the ideal model has then become to make the model $formal_2$ as well.[8]

The term ‘formal approximation’ is used to express three considerations. Firstly, the result of a *formal approximation* can be contrasted to the result of a *strict formalisation*. Formalisation in the strict sense can give rise to the impression that the original model is being replaced by the formalised model. This is not the intention with the formal approximation, which is meant to exist next to the original ideal model.

Secondly, the notion ‘formal approximation’ expresses the expectation that not all properties and aspects of the original model can be preserved. In this sense the *approximation* is comparable to the conventionalised argumentative activity types as *empirical* approximations of critical discussion developed by van Eemeren and Houtlosser (2005; van Eemeren 2010, pp. 129-162). Empirical approximations are used in the extended pragma-dialectical theory (van Eemeren 2010) to characterise the conventions of argumentative practice in reality.

Unsurprisingly, interlocutors in ordinary discourse turn out not to behave exactly in accordance with the ideal model of a critical discussion. In the same vein, if the formal approximation yields a result that diverges from the original ideal model, this could be an indication of an imperfection or obscurity in the original model, although the divergence could also be the result of the streamlining inherent in the formalisation of informal models. A reason for the divergence could be found in the expressiveness of formalisms, which is (usually) more restricted than that of natural language. Formal models have to be fully explicit and free of ambiguity to define what falls within the model and what is excluded. This restricted expressiveness will mean that the formal approximation is stricter than the original ideal model.

[6] This subsection is based in part on an earlier conference paper (Visser 2016).

[7] There are, of course, other classifications of formality. An example is Johnson and Blair’s (1991, pp. 134-135), which is partly based on the classification by Barth and Krabbe.

[8] Krabbe (2012; 2013) has proposed a system CD with the same objective: making the system *$formal_2$*.

Thirdly, the term ‘formal approximation’ is used because of the approach to developing the formal model. Instead of defining a formal model based on the pragma-dialectical ideal model in one time in its entirety, the formal approximation is developed in increments. Starting from a simplified basis, additional, complex features are gradually added in extensions.[9] In this way the scope of the formal approximation is brought ever closer to the full extent of the ideal model. This systematic approach has the practical advantage of decomposing a large task into several smaller constitutive tasks, such that these smaller tasks can be carried out in stages, at different times and by different people. Another kind of advantage is of a theoretical nature: by gradually increasing the complexity of the dialogue game, the properties of the model can be studied in isolation (without other features of the model complicating the investigation). In the incremental approach proposed here, formal approximation has become a gradual concept. A model can approximate the ideal closer or less closely, which is why the term ‘formal approximation’ is more applicable than ‘formalisation’.

In the incremental development of the formal approximation, the pragma-dialectical ideal model is interpreted as a blueprint for a dialogue game. Dialogue games are a way to describe a communicative activity in abstract, formal terms. The formalism has been employed by philosophers of language to study small portions of everyday linguistic activity in isolated and simplified form (following Wittgenstein’s (1953) use of 'language games' in his *Philosophical investigations*), by linguists to study discourse (Carlson 1983), and by logicians (Hintikka 1968; Lorenzen and Lorenz 1978), among others. The perspective on language use as intentional, action-driven interaction has since been recognised by computer scientists as a natural way to use existing computational means to model communication in multi-agent systems. There are different definitions of the notion available in the literature. I will subscribe to McBurney and Parsons’ (2009, p. 261-262) characterisation of dialogue games as “rule-governed interactions between two or more players (or agents), where each player ‘moves’ by making utterances, according to a defined set of rules.”

The aforementioned defined set of rules can be categorised into five categories. First, the commencement rules define the initial state of the game (i.e. the set-up of the board and shuffling of the cards before the game starts). Second, the move rules define the types of moves that players can make during the game. Third, the commitment rules define for each move what effect it will have on the players’ commitments (i.e. the propositions they can be held committed to). Fourth, the sequence rules define for each move under which circumstances it can be made (e.g. in response to which preceding moves). Fifth, the termination rules define when the game stops and what the winning conditions are.

5. Conclusion

My objective in this paper was to explore the way in which a formal approximation of the ideal model of a critical discussion can be developed as a preparation for computer tools to support the pragma-dialectical analysis of argumentation. To this avail, I first presented a selective overview of the integration of insights from argumentation theory and methods from computer science. Next, I characterised the pragma-dialectical method of analysis procedurally as consisting of a reconstruction sub-task and an abstraction sub-task. In addition to indicating some points at which computer tools would be of use, the procedural interpretation showed that the ideal model

[9] This incremental approach is similar to that of Walton and Krabbe (1995) in their definition of 0-versions of dialogue systems, allowing further rule modifications in 1-, 2-, and subsequent versions.

of a critical discussion fulfils a crucial role. Lastly, an incremental approach to the formal approximation of the ideal model was outlined in order to prepare the model for the computational implementation that would be necessary in the development of computer support for pragma-dialectical analysis.

The outline of the approach that I presented brings us one step further in the direction of the development of computational tools to support argumentative tasks based on the pragma-dialectical theory. Although I have not focussed on this in the current paper, the formal approximation of the pragma-dialectical discussion model can also be of benefit to computationally oriented argumentation studies. For example, the formal approximation of the ideal model may serve as a starting point in the definition of dialogue protocols for multi-agent systems. On the one hand, the ideal model is normative (implementing a critical conception of reasonableness and an instrumentally valid procedure), which makes it a good starting point to exclude fallacies from protocols. On the other hand, the ideal model is empirically tested for its conventional validity (van Eemeren, Garssen and Meuffels 2009), which makes it a good starting point for multi-agent systems in which human agents participate. In this endeavour, conventionality and experienced naturalness are important factors to take into account.

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