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Book review

A book review on *Elements of Argumentation.*

1. Synopsis

I am proud to write this review on the book entitled "Elements of Argumentations" by Philippe Besnard and Anthony Hunter. Argumentation is an important issue that is naturally used in situations where one is faced in making important decisions. For instance, if one is interested in buying a given house, he needs to analyse and confront arguments in favor of this house and arguments against it. Argumentation has a potential use in different areas and for different purposes such as: legal reasoning, negotiation, decision making, dialogue, e-democracy, medical applications, causality and reasoning about actions. Argumentation systems aim, on the basis of a collection of available conflicting information, to identify and confront arguments and counterarguments that support or object a given claim (for instance, identifying the pros and cons for buying a given house).

Argumentation constitutes an active area in Artificial Intelligence. During the last twenty years, an important number of research papers on argumentation systems have been published in major Artificial Intelligence conferences such as IJCAI (International Joint Conference on Artificial Intelligence), AAAI (National Conference on Artificial Intelligence), ECAI (European Conference on Artificial Intelligence), KR (International Conference on Principles of Knowledge Representation and Reasoning) and more recently AAMAS (International Conference on Autonomous Agents and Multiagent Systems). This is also true for major Artificial Intelligence journals. In addition to this high number of publications on argumentation, two workshops have been organised for several years: a workshop on Computational Models of Natural Argument CMNA (organised 10 times usually in conjunction with IJCAI and ECAI) and International Workshop on Argumentation in Multi-Agent Systems ArgMAS held in conjunction with AAMAS. And more recently, a Conference on Computational Model of Arguments (COMMA), dedicated to computational aspects of argumentation is organised (the third edition will be organised in Italy).

Despite the importance of the topic and the high number of published papers, there is no recent book that fully focuses on argumentation. This book arrives in a right time and the authors fully satisfy all requirements for a high quality book. Writing a book on argumentation is not an easy task because the public that may be concerned by the subject is quite large. It may concern lawyers, people working on logics, people from cognitive psychology or from multi-criteria decision making area. The authors definitely achieve their objective. In particular, they provide a good compromise between informal presentations and formal descriptions of the results. They were very successful in providing a synthetic picture of existing works, including their own research. They have tried to be as gentle as possible with the reader and the book is rich of illustrative examples (by analysing for instance several newspaper reports), that clearly demonstrated the large potential applicability of argumentation systems.

The book is composed of 9 chapters. Chapter 1 provides an easily comprehensible and comprehensive introduction to the theory of argumentation systems. Then the authors decide to present in detail two argumentation systems: the one of Dung, described in Chapter 2, and the author's argumentation system where its foundations are described in Chapter 3, while its extensions and computational issues are addressed in Chapters 4 to 7. Other existing systems are nicely described in Chapter 8. Chapter 9 contains several interesting directions in argumentation areas. Each chapter contains a clear introduction, a progressive presentation of its content, and a real discussion section with some additional references. The book is self-contained since it contains several appendices that provide necessary backgrounds on propositional logic or trees. Proofs of technical results presented in Chapters 3 and 7 of the book are provided in the appendix (proofs are only provided for propositions that are obtained by the authors). In the following, I will describe and comment the content of the book. Of course, as a reviewer, I have to disagree or object some of the authors' proposals, but there is no doubt this should not question the quality and the great job that has been done by the authors.

2. Contents

Chapter 1

The first chapter is entitled "Nature of Argumentation". It introduces in a very intuitive and natural way main concepts of an argumentation system. The authors delimit different kinds of elements that should be taken into account in order to

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define a genuine argumentation system. The authors survey important components of an argumentation system such as: arguments, contradictions, the concept of rebuttals, undercut, counterarguments, etc. All these concepts are well motivated and illustrated with different examples. The formal definitions and mathematical descriptions of these concepts are provided in later chapters (especially in Chapters 2 and 3). The authors then present different kinds of information (such as objective vs subjective knowledge) that may be used to construct arguments and argumentation frameworks. They also explain differences between monological argumentation and dialogual argumentation. The formalisation considered in the book is more oriented monological argumentation. The authors then provide requirements for formalising argumentations and briefly present three kinds of frameworks that can be used: Abstract systems (which are described in detail in Chapter 2), Defeasible systems (which are more detailed in Chapter 8) and Coherence systems (to which the authors' proposals belong). This chapter is nicely written from which a reader can quickly have a nice, non-technical, introduction to an argumentation framework.

Chapter 2

Chapter 2 contains the first argumentation system, described in the book, called abstract argumentation. This framework has been presented by Dung (Artificial Intelligence Journal, 1995). Now, Dung's framework is widely used and referenced in most existing works on argumentation. The starting point is very simple. An argumentation system is viewed as a graph. Nodes represent arguments, and arcs encode some attack relation between arguments. The term abstract argumentation comes from the fact that no information is given on the way arguments are obtained or constructed. No information is given on the internal (or logical) contents of arguments. Arguments are basic and elementary objects. Abstract argumentation may be either provided by some expert, or may be viewed as a result of some pre-processing step (or abstraction step) where all available information are summarized and "compiled" into a set of arguments equipped with some attack relation, the whole represented by a graph. Chapter 2 provides key definitions of this argumentation system such as the concept of admissible arguments, extensions, a set of conflict free arguments, etc. The reader can also find main technical results (without proofs but they are available from Dung's papers) that help understanding this system, and some extensions of this system are briefly recalled in Chapter 8. May be what is missing in the discussion section and since this system is not used in the rest of the book, a more detailed analysis of why an abstract system is not suitable to encode different facets of argumentation, and there is a need to consider another argumentation system, namely the one developed by the authors.

Chapter 3

Chapter 3 is in my opinion the core chapter of the book, in the sense that it contains basic definitions and formal descriptions of the argumentation systems developed by the authors. The chapter is entitled, "logical argumentation", probably in opposition to "abstract argumentation" presented in Chapter 2. Here, arguments are no longer abstract objects and "argument graph" is not considered as a starting point. If I were asked to provide an alternative title, I would suggest "Argument trees" or "Logical-based argument trees". The reason is that the main result of the chapter is an elegant representation of argumentation systems by argument trees. One can also see it from Chapter 7 about computational issues, where the proposed algorithms concern the construction of arguments and argument trees.

The presence of the term "logical" in the title means that the proposed argumentation system has a logic-based representation. But readers who are not experts in logic should be reassured: only standard propositional logic (and a little bit an extension to first order logic) is used. Moreover, the authors provide in an appendix, a really nice introduction to propositional logic. In this sense, this chapter (and this is true for the whole book) is self-contained. Of course, the restriction to propositional logic does not mean that the task of constructing an argumentation system is easy. The reader should be prepared to meet more or less complex results. For instance, if you (a reader) just finished reading pages 48–49 which contain important propositions, then you should be prepared to discover that the next section in page 50 is entitled "technical developments" with more propositions.

The starting point in this chapter is the notion of a knowledge base (the authors write it in one word knowledgebase). The author's view of a knowledge base, denoted by Δ, is syntactic, in the sense that, for instance, $\Delta = \{\alpha\}$ is not the same as $\Delta' = \{\alpha, \alpha \wedge \alpha\}$. In the presence of inconsistency, knowledge bases must be syntactic in nature, since they use formulas that explicitly appear in the knowledge base originally, while any two inconsistent knowledge bases over the same language are semantically equivalent (in a trivial way). Δ is a finite set (and not a multi-set) of propositional formulas.

I fully agree with the authors that it is important to consider a simple language, such as propositional logic, in order to introduce argumentation systems. I am fully convinced that if priorities, uncertainties, and more generally meta-information are integrated in the logical-based formalisation, then the chapter will be particularly heavy, and the main messages of the chapter will be drowned by technical issues raised by the use of complex non-standard logics. However, the authors claim that Δ may contain objective, subjective, uncertain pieces of information, and it is not clear how these different kinds of information can be represented in propositional logic. Similarly, the authors argue for instance that $a \vee b$ and $b \vee a$ may come from different sources, but there is no indications how to keep track of the sources that provide these pieces of information.

After discussing the nature of a knowledge base, the authors define the notion of argument in a very usual way: an argument A is a pair $A = \langle \Phi, \alpha \rangle$, where α is a propositional formula, called a claim or a conclusion, and Φ, called the support, is a minimal consistent subset of Δ that entails α. Then they define different kinds of attack relations: defeat relations, rebuttal relations, undercut relations, etc. The authors provide an extensive study of properties of these attack relations, as it is confirmed by the high number of interesting results and characterisations provided in the chapter.

An important problem when studying argumentation is how to structure the set of arguments. Here, the authors present a very elegant representation of argumentation systems, using argument trees. The originality does not reside in the use of trees as a graphical representation of sets of arguments, but in a proposition of three requirements that a tree of arguments should satisfy. The first requirement simply says that an argument tree is a tree where nodes are arguments, and for a given node that represents some argument A, its children are a set of arguments that undercut it. The second requirement says that if $\langle \Phi, \alpha \rangle$ is an undercut of its parent argument $\langle \Psi, \beta \rangle$ then α should be equivalent to $\neg\Psi$ (hence not all undercuts of an argument need to be presented). The third requirement says that there is no node argument $A = \langle \Phi, \alpha \rangle$, where all formulas of Φ already appear in supports of argument nodes that are between A's parent and the root. Namely, when constructing an argument tree, each argument added to the tree should always bring some new beliefs in order to be taken into account.

This chapter is nicely written. It is full of significant results that clearly answer many questions that one may ask regarding for instance properties of argument trees, relationships between different attack relations, or a characterisation of a consistency of a knowledge base in terms of argument trees.

May be the chapter in some of its sections is too technical. The chapter contains 54 propositions or corollaries (and 45 examples). For a better understanding of some propositions, I think that the reader can ignore the presence of individual inconsistent formulas. I am not against leaving them in, however their presence has absolutely no influence on the results obtained. For instance, the set of argument trees that can be constructed from Δ, is exactly the same as the one obtained from Δ', where Δ' is the result of removing individual inconsistent formulas from Δ. Assuming that all individual formulas in a knowledge base are consistent, helps for a better understanding of some propositions of the chapter, and permits to get rid of some particular cases in some propositions.

Besides, I am not sure to agree with the definition of *Defenders*(T) (which intuitively contains the set of defenders of the argument root in an argument tree T), and *Attackers*(T) (similarly the set of attackers of the argument root). The informal definition given by the authors is satisfying, up to two objections: i) I am not sure that an attacker of an attacker is a defender, and ii) an argument may be present in different places in an argument tree and hence it can be both a defender and an attacker. To illustrate this, consider a knowledge base containing the following five formulas:

$$\Delta = \{\alpha \wedge \beta, \alpha \wedge \beta \wedge \beta, \neg\alpha \wedge \beta, \alpha \wedge \neg\beta, \neg\alpha \wedge \neg\beta\}.$$

Consider the following six arguments:

$$\begin{aligned}
A &= \langle \{\alpha \wedge \beta\}, \alpha \rangle, \\
B &= \langle \{\neg\alpha \wedge \beta\}, \neg\alpha \vee \neg\beta \rangle, \\
C &= \langle \{\alpha \wedge \neg\beta\}, \alpha \vee \neg\beta \rangle, \\
D &= \langle \{\neg\alpha \wedge \neg\beta\}, \neg\alpha \vee \beta \rangle, \\
E &= \langle \{\alpha \wedge \beta \wedge \beta\}, \alpha \vee \beta \rangle, \\
F &= \langle \{\alpha \wedge \neg\beta\}, \neg\alpha \vee \neg\beta \rangle.
\end{aligned}$$

I will not describe the full argument tree (that I will denote by T) whose root node is A, but just give some of its paths to illustrate my remarks. If one considers the path $A \leftarrow B \leftarrow C$ then C will be considered as a defender of A since it attacks A's attacker. However, the support of C and the support of A are conflicting. In the same example, B is considered as an attacker of A, namely $B \in \mathit{Attackers}(T)$. Now let us consider another path composed of five arguments in the following order: $A \leftarrow F \leftarrow D \leftarrow E \leftarrow B$. Here, B is a defender of A, namely $B \in \mathit{Defenders}(T)$. Hence, B is both an attacker and a defender which is normal on the basis of the position of B. Again depending on the considered application, a reader can adapt this definition (and also adapt some of further definitions, given for instance in Chapter 6, that use attackers and defenders of an argument tree).

Lastly, may be what it is also missing in this chapter is a discussion on conditions where a conclusion can be considered as accepted or not, on the basis of constructed argument trees. I expected to find it in Section 3.7 concerning argument structures, but the authors only discuss its properties. Of course, in Chapters 5 and 6, the authors provide several approaches to evaluate the acceptability of an argument, but no final definition is given that tells us when a claim can be considered as accepted or not.

Chapter 4

After two chapters that formally introduced two important argumentation systems, with many important and significant technical results, Chapter 4 provides an analysis of what are practical argumentations. This chapter is well-written without real use of new formalisations. This chapter could be merged with Chapter 1, but having it at this place allows a better understanding of examples that are developed with the help of argument trees presented in Chapter 3. This chapter provides good justifications on the need of using some functions that evaluate the acceptability of an argument tree that takes into account the audience. It constitutes a nice motivation and introduction to Chapters 5 and 6.

Chapter 5

In Chapter 3, the authors formally present argumentation trees, as an elegant representation of a set of arguments. Chapters 5 and 6 go one step further by comparing arguments and taking into account the audience. Chapter 5 presents different ways to evaluate whether an argument is somewhat accepted or not, and to what extent it is conflicting. This is first done by introducing a notion of "judge function" to evaluate whether a root node is warranted or not. Basically, the authors reasonably assume that leaves are undefeated (or warranted), then they propose two "propagation" rules from leaves to root that uniquely determine whether the root node is warranted or not. The proposal looks very interesting, even if the authors do not really insist on how "good" is their judge function. For instance, I expected a remark explaining the importance of the non-removing of logically equivalent formulas. For instance, using this proposed judge function, the argument $\langle\{\alpha\},\alpha\rangle$ is considered as unwarranted in $\Delta_1=\{\alpha,\neg\alpha\}$ (which is intuitively satisfying since without additional meta-information, there is no reason to accept α rather than $\neg\alpha$). Now the same argument $\langle\{\alpha\},\alpha\rangle$ will be considered as warranted if one uses $\Delta_2=\{\alpha,\neg\alpha,\alpha\wedge\alpha\}$ (which is only satisfactory if one for instance considers that α and $\alpha\wedge\alpha$ are issued from two different sources and hence it makes sense to accept α).

The authors then correctly argue that undercut relation is a matter of degree, and these undercut degrees may be helpful (by combining them) to evaluate how much an argument tree is conflicting and to what extent it is acceptable. Before providing some undercut measures, the authors first provide a general definition (Definition 5.2.2) to measure the degree of conflicts between two arguments. In my opinion, the first condition of this definition is open to discussions, even if it is intuitive. This condition states that if the support of some argument A_i entails a support of another argument A_j, then for any argument A, the conflict degree between A_i and A should be less or equal than the one between A_j and A. Of course, this definition looks satisfactory and intuitive since for instance each minimal inconsistent subset of $\mathit{Support}(A)\cup\mathit{Support}(A_j)$ is also a minimal inconsistent subset of $\mathit{Support}(A)\cup\mathit{Support}(A_i)$. The only problem is that one may require that the highest degree of conflict between two formulas α and β is reached when α is logically equivalent $\neg\beta$ (the authors do not include such requirement, they only provide conditions that characterize minimal conflicting degrees which are reached when α and β are jointly consistent). Consider an example, where the support of A_i is $\{\alpha\wedge\beta\}$, and support of A_j is $\{\alpha\}$ (hence support of A_i entails support of A_j), and assume that the support of A is $\{\neg\alpha\}$. Namely, we have a strong conflict between supports of A and A_i on the one hand, and supports of A and A_j on the other hand. However, one may argue that the degree of conflict between A and A_j is less than the one between A and A_i. There is another reason where I think that the general requirement provided in Definition 5.2.2 is open to discussions, is that the concrete measures of conflicts (based on Hamming distances and propositional contradictions) proposed by the authors do not satisfy this requirement.

After providing a general class of conflict measures, the authors provide three concrete definitions of conflict measures. All of them are nicely described. The one based on Hamming distance or Dalal distance is very interesting. Dalal distance has been largely used in belief revision or belief merging, but in this chapter the authors show how this distance can be used to measure conflicts between formulas (supports of arguments). A negative aspect of using this distance is that it depends on the way formulas of the knowledge base are written (this is the price to pay if one offers flexibility in encoding knowledge bases). For instance, let $A=\langle\{\alpha\},\alpha\rangle$, $B=\langle\{\alpha\wedge(\alpha\vee\beta)\},\alpha\rangle$, $C=\langle\{\neg\alpha\},\neg\alpha\rangle$, using the conflict measure based on Dalal distance one gets $\mathit{Conflict}(A,C)$ different from $\mathit{Conflict}(B,C)$ while β is irrelevant in argument B. Of course, if one considers this example as counter-intuitive, then it is easy to fix it. The chapter provides useful basic ingredients to define conflicts measures (as well as other concepts introduced in the chapter). The reader is free to adapt them for particular situations or applications.

Now, there is another definition where I am not very convinced. It concerns the tension measure provided in Definition 5.2.8. The reason why I disagree with this definition, is that in argument trees, there are arguments which agree with the root of an argument tree, while other arguments are really conflicting with the root argument (especially children of the root argument). Using a sum on undercut conflict degrees (between all pairs of arguments that are related with undercut relation in an argument tree) cannot help making this distinction. For instance, consider again $\Delta_1=\{\alpha,\neg\alpha\}$, and one argument tree with two nodes $A=\langle\{\alpha\},\alpha\rangle$ and $B=\langle\{\neg\alpha\},\neg\alpha\rangle$, where B is a child of the root node A. The tension associated with this tree is 1. Now, consider $\Delta_2=\{\alpha,\alpha\wedge\alpha,\neg\alpha\}$, with an argument tree with three nodes A, B and $C=\langle\{\alpha\wedge\alpha\},\alpha\rangle$, with C as a child of B, B as a child of A and A is a root node of the tree. Here, the tension of this tree is 2. Therefore, if one uses tension degrees, α will be more accepted in the first tree rather than in a second tree (which somewhat contradicts the judge function defined earlier).

Lastly, the authors propose several convincing ways to prune, condense or compress argument trees (not all arguments are useful for a given purpose). The ideas of "overzaleous" argument is interesting (even if the example, provided to illustrate this notion, deals more with irrelevant statement).

Chapter 6

Chapter 6 addresses a very difficult problem in argumentation: how to take into account the audience? The authors already argued that the selection of "good" arguments clearly depends on the considered purposes and audience. They provide very nice and convincing examples illustrating for instance that the argumentation used by a government to increase some taxes should differ from one audience to another. Then the authors formalize it by proposing a logical encoding of the audience by means of concern base, which is a function η that assigns weights to formulas. Concern base contains information (with some importance degrees) that an agent would like to be satisfied. Only formulas having a weight greater than "0" are considered. The authors do not impose any conditions on a concern base, in particular the usual property "if $\beta \vdash \alpha$ then $\eta(\alpha) \leqslant \eta(\beta)$" need not be satisfied. I think that we need such a property, since in practice a concern base is not explicitly defined for all the language. And there is a need of such a property (or other natural property) to extend it to the whole language.

Then the authors define the concept of the impact of an argument, represented by a function called resonance, and which is computed using the function η. There is one thing that I would take issue with is that the impact of an argument, with respect to an agent, is the same if she prefers α or $\neg\alpha$. The authors also suggest to encode an audience's belief base. The idea is that the more the argument is consistent with what the audience believes, the more the argument will be convincing. Given a belief base $\bigwedge$, they define the empathy basically as the number of models that the support of the argument share with this belief base. They also define the antipathy as the conflict degree (defined in Chapter 5) between audience's belief base and the support of the arguments. This gives a natural definition of the empathy of an argument tree, by adding the empathy of all of its defenders minus the empathy of its attackers. All these very interesting concepts are illustrated with many examples (there is a minor error in Example 6.2.4 where the empathy of the first argument is 1/4 instead of 0).

Chapter 7

Chapter 7 deals with computational issues. First, the authors propose "naive" algorithms (in a sense an exhaustive search algorithm) that given a knowledge base Δ and a formula α produce an argument tree (a very minor detail: in the algorithm given in 7.1.2, one needs to add an instruction that checks if there is indeed at least one argument in favor of α, and if it is the case one should add an instruction $N = \{\langle \Phi, \alpha \rangle\}$ just before the while loop). Then the authors propose a compilation algorithm that allows to efficiently construct argument trees. The compilation is achieved by computing all minimal inconsistent subbases offline. The authors provide all needed technical details (illustrated with many examples) that show the soundness of the proposed algorithm. This chapter is definitely interesting and useful. Some of proposed algorithms may be improved for instance by analysing compact representations of a set of minimal inconsistent sets.

Chapters 8 and 9

Chapter 8 is a related works study. It represents a really nice survey of existing works on argumentation frameworks. It contains argumentation systems that are based on propositional logics, defeasible logic, logic programming, that integrate preferences, etc. For each reviewed system, the authors point out the differences with their proposals. May be, in some sections, there is a need of more precise comparative studies. For instance, in Fig. 8.1. the authors may precise that each argument A in $AF(\Delta)$ is such that there exists an argument tree that only admits one node which is A (and conversely).

Chapter 9 presents several interesting challenges for future developments of argumentation systems. May be what is missing is a subsection about applications of argumentation systems (however, the authors provide many potential applications in earlier chapters of the book).

3. Conclusions

It was really a pleasure to read this book. It is full of convincing arguments and illustrative examples from real life and newspaper articles (with even some examples in French). The book is carefully written with a perfect balance between informal presentations and technical details. I am absolutely not surprised about the quality and the maturity of the book. It is simply a result of several years of high quality research, achieved by the authors, on argumentation and some connected areas such as non-monotonic reasoning or inconsistency handling. There is absolutely no doubt that the book is a good starting point for students who may be interested in argumentation. The book contains an impressive set of technical results (with proofs and illustrative examples) that allow us to understand in depth argumentation systems. Chapters 1, 4, 9 and some part of Chapter 3 are very useful for people that are not familiar with logic (and who do not have time to read the background provided in the appendix). The book is definitely useful for students, people working on non-monotonic reasoning, belief revision, etc., but also for people that just need to have a general idea about argumentation systems.

I will now conclude with a technical proposition. Assume that we have a knowledge base Δ, and we are interested to construct an argument tree, where the claim of the argument root is: "This book *Elements of Argumentation by Philippe Besnard and Anthony Hunter* should be recommended", then whatever is the concern base, the audience, the measure of conflicts that you are using, you will always get a warranted argument tree. The proof is obvious once you read the book. It will definitely be a reference for next years.

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