

Argumentation and explainable artificial intelligence: a survey

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Abstract

Argumentation and eXplainable Artificial Intelligence (XAI) are closely related, as in the recent years, Argumentation has been used for providing Explainability to AI. Argumentation can show step by step how an AI System reaches a decision; it can provide reasoning over uncertainty and can find solutions when conflicting information is faced. In this survey, we elaborate over the topics of Argumentation and XAI combined, by reviewing all the important methods and studies, as well as implementations that use Argumentation to provide Explainability in AI. More specifically, we show how Argumentation can enable Explainability for solving various types of problems in decision-making, justification of an opinion, and dialogues. Subsequently, we elaborate on how Argumentation can help in constructing explainable systems in various applications domains, such as in Medical Informatics, Law, the Semantic Web, Security, Robotics, and some general purpose systems. Finally, we present approaches that combine Machine Learning and Argumentation Theory, toward more interpretable predictive models.

1 Introduction

Explainability of an Artificial Intelligence (AI) system (i.e., tracking the steps that lead to the decision) was an easy task in the early stages of AI, as the majority of the systems were logic-based. For this reason, it was easy to provide transparency to their decisions by providing explanations and therefore to gain the trust of their users. This changed in the last 20 yr, when data-driven methods started to evolve and became part of most AI systems, giving them computational capabilities and learning skills that cannot easily be reached by means of logic languages alone. Eventually, the steadily increasing complexity of computational evolution of AI methods resulted in more obscure systems.

Therefore, a new research field appeared in order to make AI systems more explainable, called eXplainable Artificial Intelligence (XAI). The graph is presented in Figure 1, showing the Google searches that contain the keyword XAI is very interesting, as it shows that people's searches are steadily increasing since the mid of 2016, indicating the interest in explaining decisions in AI (the picture was part of the study Adadi & Berrada 2018). Capturing an accurate definition of what can be considered an explanation is quite challenging, as can be seen in Miller (2019). Among many definitions, some commonly accepted ones are:

- An explanation is an assignment of causal responsibility (Josephson & Josephson 1996).
- An explanation is both a process and a product that is it is the process and the result of a Why? question, Lombrozo (2006).
- An explanation is a process to find meaning or create shared meaning, Miller (2004).

Argumentation In Artificial Intelligence

P. E. Dunne

Argumentation In Artificial Intelligence:

Argumentation in Artificial Intelligence Iyad Rahwan,2009-06-13 Argumentation is all around us Letters to the Editor often make points of consistency and Why is one of the most frequent questions in language asking for reasons behind behaviour And argumentation is more than reasoning in the recesses of single minds since it crucially involves interaction It cements the coordinated social behaviour that has allowed us in small bands of not particularly physically impressive primates to dominate the planet from the mammoth hunt all the way up to organized science This volume puts argumentation on the map in the field of Artificial Intelligence This theme has been coming for a while and some famous pioneers are chapter authors but we can now see a broader systematic area emerging in the sum of topics and results As a logician I find this intriguing since I see AI as logic continued by other means reminding us of broader views of what my discipline is about Logic arose originally out of reflection on many agent practices of disputation in Greek Antiquity but also in India and China And logicians like me would like to return to this broader agenda of rational agency and intelligent interaction Of course Aristotle also gave us a formal systems methodology that deeply influenced the field and eventually connected up happily with mathematical proof and foundations

Argumentation in Multi-Agent Systems Nicolas Maudet,Simon D. Parsons,Iyad Rahwan,2007-11-04 Argumentation provides tools for designing implementing and analyzing sophisticated forms of interaction among rational agents It has made a solid contribution to the practice of multiagent dialogues This book constitutes the thoroughly refereed post proceedings of the Third International Workshop on Argumentation in Multi Agent Systems held in Hakodate Japan as an associated event of AAMAS 2006 the main international conference on autonomous agents and multi agent systems

Argumentation Machines C. Reed,T.J. Norman,2013-03-09 In the late 1990s AI witnessed an increasing use of the term argumentation within its bounds in natural language processing in user interface design in logic programming and nonmonotonic reasoning in AI's interface with the legal community and in the newly emerging field of multi agent systems It seemed to me that many of these uses of argumentation were inspired by of ten inspired guesswork and that a great majority of the AI community were unaware that there was a maturing rich field of research in Argumentation Theory and Critical Thinking and Informal Logic that had been steadily re building a scholarly approach to the area over the previous twenty years or so Argumentation Theory on its side was developing theories and approaches that many in the field felt could have a role more widely in research and society but were for the most part unaware that AI was one of the best candidates for such application

Computational Models of Argument Francesco Santini,Carlo Taticchi,2020-09-15 The investigation of computational models of argument is a rich and fascinating interdisciplinary research field with two ultimate aims the theoretical goal of understanding argumentation as a cognitive phenomenon by modeling it in computer programs and the practical goal of supporting the development of computer based systems able to engage in argumentation related activities with human users or among themselves The biennial International

Conferences on Computational Models of Argument COMMA provide a dedicated forum for the presentation and discussion of the latest advancements in the field and cover both basic research and innovative applications This book presents the proceedings of COMMA 2020 Due to the Covid 19 pandemic COMMA 2020 was held as an online event on the originally scheduled dates of 8 11 September 2020 organised by the University of Perugia Italy The book includes 28 full papers and 13 short papers selected from a total of 78 submissions the abstracts of 3 invited talks and 13 demonstration abstracts The interdisciplinary nature of the field is reflected and contributions cover both theory and practice Theoretical contributions include new formal models the study of formal or computational properties of models designs for implemented systems and experimental research Practical papers include applications to medicine law and criminal investigation chatbots and online product reviews The argument mining trend from previous COMMA s is continued while an emerging trend this year is the use of argumentation for explainable AI The book provided an overview of the latest work on computational models of argument and will be of interest to all those working in the field Argumentation Methods for Artificial Intelligence in Law

Douglas Walton,2005-09-30 During a recent visit to China to give an invited lecture on legal argumentation I was asked a question about conventional opinion in western countries If legal reasoning is thought to be important by those both inside and outside the legal profession why does there appear to be so little attention given to the study of legal logic This was a hard question to answer I had to admit there were no large or well established centers of legal logic in North America that I could recommend as places to study Going through customs in Vancouver the customs officer asked what I had been doing in China I told him I had been a speaker at a conference He asked what the conference was on I told him legal logic He asked 1 whether there was such a thing He was trying to be funny but I thought he had a good point People will question whether there is such a thing as legal logic and some recent very prominent trials give the question some backing in the common opinion But having thought over the question of why so little attention appears to be given to legal logic as a mainstream subject in western countries I think I now have an answer The answer is that we have been looking in the wrong place

Logical Models of Legal Argumentation Henry Prakken,Giovanni Sartor,1997 In the study of forms of legal reasoning logic and argumentation theory long followed separate tracks Recently however developments in Artificial Intelligence and Law have paved the way for overcoming this separation Logic has widened its scope to defeasible argumentation and informal accounts of analogy and dialectics have inspired the construction of computer programs Thus the prospect is emerging of an integrated logical and dialectical account of legal argument adding to the understanding of legal reasoning and providing a formal basis for computer tools that assist and mediate legal debates while leaving room for human initiative

Theory and Applications of Formal Argumentation Sanjay Modgil,Nir Oren,Francesca Toni,2012-03-26 This book constitutes the thoroughly refereed proceedings of the First International Workshop on the Theory and Applications of Formal Argumentation TAFA 2011 held in Barcelona Spain in July 2011 as a workshop at IJCAI 2011 the 22nd International

Joint Conference on Artificial Intelligence The 9 revised full papers presented together with 8 revised poster papers were carefully selected during two rounds of reviewing and improvement from 32 initial submissions The workshop promotes and fosters uptake of argumentation as a viable AI paradigm with wide ranging application and provides a forum for further development of ideas and the initiation of new and innovative collaborations The papers cover the following topics properties of formal models of argumentation instantiations of abstract argumentation frameworks relationships among different argumentation frameworks practical applications of formal models of argumentation argumentation and other artificial intelligence techniques evaluation of formal models of argumentation validation and evaluation of applications of argumentation

Efficient Computation of Argumentation Semantics Beishui Liao,2013-12-27 Efficient Computation of Argumentation Semantics addresses argumentation semantics and systems introducing readers to cutting edge decomposition methods that drive increasingly efficient logic computation in AI and intelligent systems Such complex and distributed systems are increasingly used in the automation and transportation systems field and particularly autonomous systems as well as more generic intelligent computation research The Series in Intelligent Systems publishes titles that cover state of the art knowledge and the latest advances in research and development in intelligent systems Its scope includes theoretical studies design methods and real world implementations and applications The series publishes titles in three core sub topic areas intelligent automation intelligent transportation systems and intelligent computing The first book to cover new methods for computing static dynamic and partial argumentation systems Methods are applicable to development of systems and research areas in both AI and broader intelligent systems Provides the AI and IS community with insight into the critical field of efficient computation with a focus on intelligent automation intelligent transportation systems and intelligent computing

Argumentation in Multi-Agent Systems Simon D. Parsons,Nicolas Maudet,Pavlos Moraitis,Iyad Rahwan,2006-07-25 This book constitutes the thoroughly refereed post proceedings of the Second International Workshop on Argumentation in Multi Agent Systems held in Utrecht Netherlands in July 2005 as an associated event of AAMAS 2005 the main international conference on autonomous agents and multi agent systems The 10 revised full papers presented together with an invited paper were carefully reviewed and selected from 17 submissions The papers are organized in topical sections on foundations negotiation protocols deliberation and coalition formation and consensus formation

From Knowledge Representation to Argumentation in Ai, Law and Policy Making. a Festscript in Honour of Trevor Bench-Capon on the Occasion of His 60th Katie Atkinson,Henry Prakken,Adam Wyner,2013-11-01 Trevor Bench Capon is well recognised as an outstanding figure in Artificial Intelligence and Law having published extensively over the long course of his career on legal knowledge representation engineering methods for knowledge based systems theoretical and applied argumentation case based reasoning policy making reasoning about evidence and many other related topics He has deeply influenced many of his colleagues particularly with his earlier work on principled methods for legal knowledge representation and the

engineering of knowledge based systems and later with the introduction of values in the study of argumentation This Festschrift is in honour of Bench Capon s work and its seminal influence The articles contained here by his colleagues extensively review comment on and extend Bench Capon s work As a whole the volume is a substantive introduction to the main topics and issues to which Bench Capon has contributed so much **Argumentation in Multi-Agent Systems** Peter McBurney,Iyad Rahwan,Simon D. Parsons,2012-02-21 This book constitutes the thoroughly reviewed post proceedings of the 7th International Workshop on Argumentation in Multi Agent Systems ArgMas 2010 held in Toronto Canada in May 2010 as a satellite workshop of AAMAS 2010 The 14 revised full papers taken from ArgMAS 2010 were carefully reviewed and improved during two rounds of revision Also included are 4 invited papers based on presentations on argumentation at the AAMAS 2010 main conference All together the 18 papers included in the book give a representative overview on current research on argumentation in multi agent systems The papers are organized in topical sections on practical reasoning and argument about action applications and theoretical aspects **Theory and Applications of Formal Argumentation** Elizabeth Black,Sanjay Modgil,Nir Oren,2016-01-06 This book constitutes the refereed proceedings of the Third International Workshop on the Theory and Applications of Formal Argumentation TAFA 2015 held in Buenos Aires Argentina in July 2015 The workshop was co located with IJCAI 2015 The 15 revised full papers presented were carefully reviewed and selected from 25 submissions The papers deal with formal theoretical models of argumentation and application of such models in subfields of AI evaluation of models both theoretical and practical and theories and applications developed through inter disciplinary collaboration **Computational Models of Argument** P. E. Dunne,2006 Argumentation is an important sub discipline of Artificial Intelligence The process of interpreting and exploiting classical treatments of Argumentation Theory in effective computational terms has led to a rich interchange of ideas among researchers This book offers an overview of the research issues and concerns within this field **Theory and Applications of Formal Argumentation** Elizabeth Black,Sanjay Modgil,Nir Oren,2014-02-03 This book constitutes the refereed proceedings of the second International Workshop on the Theory and Applications of Formal Argumentation TAFA 2013 held in Beijing China in August 2013 The Workshop was co located with IJCAI 2013 The 15 revised full papers presented were carefully reviewed and selected from 22 submissions The papers are organized in topical sections such as abstract argumentation frameworks social abstract argumentation with votes on attacks a normal form of argumentation frameworks assumption based argumentation argument schemes for normative practical reasoning **Computational Models of Argument** Philippe Besnard,Sylvie Doutre,Anthony Hunter,2008 Focuses on the aim to develop software tools to assist users in constructing and evaluating arguments and counterarguments and or to develop automated systems for constructing and evaluating arguments and counterarguments This book includes articles which provide a snapshot of research questions in the area of computational models of argument

Argumentation in Multi-Agent Systems Iyad Rahwan,Pavlos Moraitis,2009-02-16 During the last decade Argumentation

has been gaining importance within Artificial Intelligence especially in multi agent systems Argumentation is a powerful mechanism for modelling the internal reasoning of an agent It also provides tools for analysing designing and implementing sophisticated forms of interaction among rational agents thus making important contributions to the theory and practice of multiagent dialogues Application domains include nonmonotonic reasoning legal disputes business negotiation labor disputes team formation scientific inquiry deliberative democracy ontology reconciliation risk analysis scheduling and logistics This volume presents the latest developments in this area at the interface of argumentation theory and multi agent systems The 10 revised full papers presented together with 3 invited papers from the AAMAS 2008 conference were carefully reviewed and selected from numerous submissions The papers are organized in topical sections on argument based reasoning argumentation and dialogue as well as strategic and pragmatic issues

Computational Models of Argument B.

Verheij,S. Szeider,S. Woltran,2012-09-04 The subject of argumentation has been studied since ancient times but it has seen major innovations since the advent of the computer age Software already exists which can create and evaluate arguments in high stake situations such as medical diagnosis and criminal investigation formal systems can help us appreciate the role of the value judgments which underlie opposing positions and it is even possible to enter into argumentative dialogues as if playing a computer game This book presents the 28 full papers 17 short papers and a number of system demonstrations described in an extended abstract from the 2012 biennial Computational Models of Argument COMMA conference held in Vienna Austria Papers by the invited speakers Professor Trevor Bench Capon Professor Erik Krabbe and Professor Keith Stenning are also included This year for the first time COMMA invited the submission of papers for an innovative applications track and those which were accepted for presentation are included in this volume Argumentation can be studied from many angles including the artificial natural and theoretical systems perspective Presentations at the 2012 conference addressed the subject from these perspectives and many more

Algorithms for Computational Argumentation in Artificial Intelligence

V. Efstathiou,2011 *Computational Models of Argument* P. Baroni,T.F. Gordon,T. Scheffler,2016-09-02

Research into computational models of argument is a rich interdisciplinary field involving the study of natural artificial and theoretical argumentation and requiring openness to interactions with a variety of disciplines ranging from philosophy and cognitive science to formal logic and graph theory The ultimate aim is to support the development of computer based systems able to engage in argumentation related activities either with human users or among themselves This book presents the proceedings of the sixth biennial International Conference on Computational Models of Argument COMMA 2016 held in Potsdam Germany on 12 16 September The aim of the COMMA conferences is to bring together researchers interested in computational models of argument and the representation of argumentation structures in natural language texts with special attention to contributions concerning emerging trends and the development of new connections with other areas The book contains the 25 full papers 17 short papers and 10 demonstration abstracts presented at the conference together with 3

invited talks Subjects covered include abstract bipolar and structured argumentation quantitative approaches and their connections with formalisms like Bayesian networks and fuzzy logic multi agent scenarios algorithms and solvers and mining arguments in text dialogue and social media The book provides an overview of current research and developments in the field of computational models of argument and will be essential reading for all those with an interest in the field

Dynamics, Uncertainty and Reasoning Beishui Liao,Thomas Ågotnes,Yi N. Wang,2019-07-23 This volume collects selected papers presented at the Second Chinese Conference on Logic and Argumentation in 2018 held in Hangzhou China The papers presented reflect recent advances in logic and argumentation as well as the connections between the two and also include invited papers contributed by leading experts in these fields The book covers a wide variety of topics related to dynamics uncertainty and reasoning It continues discussions on the interplay between logic and argumentation which has a long history from Aristotle's ancient logic to very recent formal argumentation in AI

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