On Bimodal Nonmonotonic Logics and Their Unmodal and Nonmodal Equivalents

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Abstract

We study a bimodal nonmonotonic logic MBNF suggested in [Lifschitz, 1994] as a generalization of a number of nonmonotonic formalisms. We show first that it is equivalent to a certain nonmodal system involving rules of a special kind. Next, it is shown that the latter admits a modal representation that uses only one modal operator, the operator of belief. Moreover, under this translation the models of MBNF correspond to "expansions" of the associated modal nonmonotonic logic. Finally we show that, as far as such models are concerned, MBNF is redunahle to nonmodal default consequence relations from [Bochman, 1994]. These results have general consequences concerning relationship between different formalizations of nonmonotonic reasoning.

Introduction

In many respects the logic of belief and negation as failure (MBNF) suggested in [Lifschitz 1994] can be seen as a most general formalism for nonmonotonic reasoning that provides a unifying framework both for logic programming and for such nonmonotonic systems as default and autoepistemic logic. In this paper WE consider the relation of MBNF to other nonmonotonic formalisms. Our main results are twofold. On the one hand, MBNF is shown to be reducible to usual unimodal nonmonotonic logics. On the other hand, we also show that it can be reduced to nonmodal default consequence relations from [Bochman, 1993, 1994].

The paper is organized as follows. We show first that MBNF is equivalent to a certain nonmodal system called a BNF-consequence relation that involves rules or sequents of a special kind. In this framework we define a counterpart of MBNF and the notion of an L-expansion that can be considered as their 'core'. In addition, we introduce the notion of an L-extension that also turns out to correspond to well known objects from other nonmonotonic formalisms. Next we show that BNF-consequence relations admit a modal representation that uses only one modal operator, the operator of belief. Moreover, under this translation, L-expansions

correspond to S-expansions (in the sense of [Marek et al 1993]) of the associated modal nonmonotonic logic. Finally we show that, as far as Lifschitz models are concerned, MBNF is reducible to nonmodal default consequence relations from [Bochman, 1994].

These results have important implications for a general theory of nonmonotonic reasoning. They show, in effect, that many apparently different nonmonotonic formalisms are actually different representations of the same basic assumptions and reasoning principles.

1 MBNF and its reductions

The language of MBNF involves two independent modal operators, B for belief and not for negation as failure. As the majority of nonmonotonic systems, MBNF involves two components. One is a (monotonic) logical system, the other is the notion of a model that generates the corresponding nonmonotonic inference. The system is characterized semantically. MBNF interpretations are triples of the form (I, S^B, S^n), where I is an ordinary interpretation (a set of atomic propositions) and S^B, S^n are sets of such interpretations. Such triples are used to define the notion of truth as follows:

(i) If F is an atom, F is true in (I, S^B, S^n) iff $F \in I$.

(ii) $\neg F$ is true in (I, S^B, S^n) iff F is not true in (I, S^B, S^n).

(iii) $F \wedge G$ is true in (I, S^B, S^n) iff F and G are both true in (I, S^B, S^n).

(iv) $\mathbf{B}F$ is true in (I, S^B, S^n) iff for all $J \in S^B$, F is true in (J, S^B, S^n).

(v) $\mathrm{not}\,F$ is true in (I, S^B, S^n) iff for some $J \in S^n$, F is not true in (J, S^B, S^n).

Note that there is nothing nonmonotonic in the above conditions, they can be seen as a semantic description of the host monotonic logical system for MBNF. The nonmonotonic component of MBNF is embodied in the notion of a model. A model of a theory T is defined by Lifschitz as a pair (I, S) such that T is true in (I, S, S) and there are no J, S' such that S' properly includes S and T is true in (J, S', S). This notion of a model gives rise to a corresponding notion of entailment, which is already nonmonotonic.

To begin with, note that the semantic characterization of MBNF gives rise to natural monotonic notions of

[Nonmonotonic Logics](#)

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Nonmonotonic Logics:

  Nonmonotonic Logics Karl Schlechta,1997-01-15 Nonmonotonic logics were created as an abstraction of some types of common sense reasoning analogous to the way classical logic serves to formalize ideal reasoning about mathematical objects These logics are nonmonotonic in the sense that enlarging the set of axioms does not necessarily imply an enlargement of the set of formulas deducible from these axioms Such situations arise naturally for example in the use of information of different degrees of reliability This book emphasizes basic concepts by outlining connections between different formalisms of nonmonotonic logic and gives a coherent presentation of recent research results and reasoning techniques It provides a self contained state of the art survey of the area addressing researchers in AI lo   Nonmonotonic Logic V. Wiktor Marek,Miroslaw Truszczynski,2013-03-14 When I first participated in exploring theories of nonmonotonic reasoning in the late 1970s I had no idea of the wealth of conceptual and mathematical results that would emerge from those halting first steps This book by Wiktor Marek and Miroslaw Truszczynski is an elegant treatment of a large body of these results It provides the first comprehensive treatment of two influen tial nonmonotonic logics autoepistemic and default logic and describes a number of surprising and deep unifying relationships between them It also relates them to various modal logics studied in the philosophical logic litera ture and provides a thorough treatment of their applications as foundations for logic programming semantics and for truth maintenance systems It is particularly appropriate that Marek and Truszczynski should have authored this book since so much of the research that went into these results is due to them Both authors were trained in the Polish school of logic and they bring to their research and writing the logical insights and sophisticated mathematics that one would expect from such a background I believe that this book is a splendid example of the intellectual maturity of the field of artificial intelligence and that it will provide a model of scholarship for us all for many years to come Ray Reiter Department of Computer Science University of Toronto Toronto Canada M5S 1A4 and The Canadian Institute for Advanced Research Table of Contents 1 1 Introduction   *Nonmonotonic Logic* Christian Straßer,2025-08-31 Nonmonotonic logics serve as formal models of defeasible reasoning a type of reasoning where conclusions are drawn absent absolute certainty Defeasible reasoning takes place when scientists interpret experiments in medical diagnosis and in practical everyday situations Given its wide range of applications nonmonotonic logic is of interest to philosophy psychology and artificial intelligence This Element provides a systematic introduction to the multifaceted world of nonmonotonic logics Part I familiarizes the reader with basic concepts and three central methodologies formal argumentation consistent accumulation and semantic methods Parts II IV provide a deeper understanding of each of these methods by introducing prominent logics within each paradigm Despite the apparent lack of unification in the domain of nonmonotonic logics this Element reveals connections between the three paradigms by demonstrating translations among them Whether you re a novice or an experienced traveler this Element provides a reliable map for navigating the landscape of nonmonotonic logic

Explanatory Nonmonotonic Reasoning Alexander Bochman,2005-01-19 Many approaches in the field of nonmonotonic and commonsense reasoning are actually different representations of the same basic ideas and constructions This book gives a logical formalization of the original explanatory approach to nonmonotonic reasoning It uses the basic formalism of biconsequence relations as well as derived systems of default autoepistemic and causal inference to cover in a single framework such diverse systems as default logic autoepistemic and modal nonmonotonic logics input output and causal logics argumentation theory and semantics of general logic programs with negation as failure This approach provides a clear separation between logical monotonic and nonmonotonic aspects of nonmonotonic reasoning The separation allows in particular to single out the logics underlying modern logic programming and restore thereby the connection between logic programming and logic **The Many Valued and Nonmonotonic Turn in Logic** Dov M. Gabbay,John Woods,2007-08-13 The present volume of the Handbook of the History of Logic brings together two of the most important developments in 20th century non classical logic These are many valuedness and non monotonicity On the one approach in deference to vagueness temporal or quantum indeterminacy or reference failure sentences that are classically non bivalent are allowed as inputs and outputs to consequence relations Many valued dialetheic fuzzy and quantum logics are among other things principled attempts to regulate the flow through of sentences that are neither true nor false On the second or non monotonic approach constraints are placed on inputs and sometimes on outputs of a classical consequence relation with a view to producing a notion of consequence that serves in a more realistic way the requirements of real life inference Many valued logics produce an interesting problem Non bivalent inputs produce classically valid consequence statements for any choice of outputs A major task of many valued logics of all stripes is to fashion an appropriately non classical relation of consequence The chief preoccupation of non monotonic and default logicians is how to constrain inputs and outputs of the consequence relation In what is called left non monotonicity it is forbidden to add new sentences to the inputs of true consequence statements The restriction takes notice of the fact that new information will sometimes override an antecedently and reasonably derived consequence In what is called right non monotonicity limitations are imposed on outputs of the consequence relation Most notably perhaps is the requirement that the rule of or introduction not be given free sway on outputs Also prominent is the effort of paraconsistent logicians both preservationist and dialetheic to limit the outputs of inconsistent inputs which in classical contexts are wholly unconstrained In some instances our two themes coincide Dialetheic logics are a case in point Dialetheic logics allow certain selected sentences to have as a third truth value the classical values of truth and falsity together So such logics also admit classically inconsistent inputs A central task is to construct a right non monotonic consequence relation that allows for these many valued and inconsistent inputs The Many Valued and Non Monotonic Turn in Logic is an indispensable research tool for anyone interested in the development of logic including researchers graduate and senior undergraduate students in logic history of logic mathematics history of mathematics computer science AI linguistics

cognitive science argumentation theory and the history of ideas Detailed and comprehensive chapters covering the entire range of modal logic Contains the latest scholarly discoveries and interprative insights that answers many questions in the field of logic   A New Perspective on Nonmonotonic Logics Dov M. Gabbay,Karl Schlechta,2016-11-05 In this book the authors present new results on interpolation for nonmonotonic logics abstract function independence the Talmudic Kal Vachomer rule and an equational solution of contrary to duty obligations The chapter on formal construction is the conceptual core of the book where the authors combine the ideas of several types of nonmonotonic logics and their analysis of natural concepts into a formal logic a special preferential construction that combines formal clarity with the intuitive advantages of Reiter defaults defeasible inheritance theory revision and epistemic considerations It is suitable for researchers in the area of computer science and mathematical logic   *Nonmonotonic Reasoning* Grigoris Antoniou,Mary-Anne Williams,1997 Nonmonotonic reasoning provides formal methods that enable intelligent systems to operate adequately when faced with incomplete or changing information In particular it provides rigorous mechanisms for taking back conclusions that in the presence of new information turn out to be wrong and for deriving new alternative conclusions instead Nonmonotonic reasoning methods provide rigor similar to that of classical reasoning they form a base for validation and verification and therefore increase confidence in intelligent systems that work with incomplete and changing information Following a brief introduction to the concepts of predicate logic that are needed in the subsequent chapters this book presents an in depth treatment of default logic Other subjects covered include the major approaches of autoepistemic logic and circumscription belief revision and its relationship to nonmonotonic inference and briefly the stable and well founded semantics of logic programs   **Nonmonotonic Reasoning** Gerhard Brewka,1991-01-25 This 1991 book gives an overview of different areas of research in nonmonotonic reasoning The guiding principles are clarification of the different research activities in the area and appreciation of the fact that these research activities often represent different means to the same ends namely sound theoretical foundations and efficient computation   **An Introduction to Default Logic** Philippe Besnard,1989-09-29 This book is written for those who are interested in a fonnalization of human reasoning especially in order to build intelligent computer systems Thus it is mainly designed for the Artificial Intelligence community both students and researchers although it can be useful for people working in related fields like cognitive psychology The major theme is not Artificial Intelligence applications although these are discussed throughout in sketch fonn Rather the book places a heavy emphasis on the fonnal development of default logic results and problems Default logic provides a fonnalism for an important part of human reasoning Default logic is specifically concerned with common sense reasoning which has recently been recognized in the Artificial Intelligence literature to be of fundamental importance for knowledge representation Previously fonnalized reasoning systems failed in real world environments though succeeding with an acceptable ratio in well defined environments This situation enabled empirical explorations and the design of systems

without theoretical justification In particular they could not be compared since there was no basis to judge their respective merits Default logic turned out to be very fruitful by proving the correctness of some of them We hope that this book will initiate other successful developments in default logic *Formal Methods for Nonmonotonic and Related Logics* Karl Schlechta,2018-11-03 The two volumes in this advanced textbook present results proof methods and translations of motivational and philosophical considerations to formal constructions In this Vol I the author explains preferential structures and abstract size In the associated Vol II he presents chapters on theory revision and sums defeasible inheritance theory interpolation neighbourhood semantics and deontic logic abstract independence and various aspects of nonmonotonic and other logics In both volumes the text contains many exercises and some solutions and the author limits the discussion of motivation and general context throughout offering this only when it aids understanding of the formal material in particular to illustrate the path from intuition to formalisation Together these books are a suitable compendium for graduate students and researchers in the area of computer science and mathematical logic Logic Programming and Non-monotonic Reasoning ,2004 *Principles of Knowledge Representation and Reasoning* James Allen,Richard E. Fikes,Erik Sandewall,1991 The proceedings of the Second International Conference on title held in Cambridge Massachusetts April 1991 comprise 55 papers on topics including the logical specifications of reasoning behaviors and representation formalisms comparative analysis of competing algorithms and formalisms and ana **Non-monotonic Reasoning** Michael Reinfrank,1989 Lecture notes in artificial intelligence is a subseries of computer science and has not been given a separate numbering system This is the proceedings of the Second International Workshop Grassau FRG June 1988 Not indexed Annotation copyright Book News Inc Portland Or Logic Programming and Nonmonotonic Reasoning Michael Gelfond,Nicole Leone,Gerald Pfeifer,2003-06-26 This book constitutes the refereed proceedings of the 5th International Conference on Logic Programming and Nonmonotonic Reasoning LPNMR 99 held in El Paso Texas USA in December 1999 The volume presents 26 contributed papers and four invited talks three appearing as extended abstracts and one as a full paper Topics covered include logic programming non monotonic reasoning knowledge representation semantics complexity expressive power and implementation and applicatons *Logic Programming and Non-Monotonic Reasoning* Lua-S Moniz Pereira,Anil Nerode,1993 This is the second in a series of workshops that are bringing together researchers from the theoretical end of both the logic programming and artificial intelligence communities to discuss their mutual interests This workshop emphasizes the relationship between logic programming and non monotonic reasoning Luis Moniz Pereira is Professor in the Department of Computer Science at the Universidade Nova Lisboa Portugal Anil Nerode is Professor and Director of the Mathematical Sciences Institute at Cornell University Topics include Stable Semantics Autoepistemic Logic Abduction Implementation Issues Well founded Semantics Truth Maintenance Probabilistic Theories Applications Default Logic Diagnosis Complexity and Theory Handling Inconsistency **Symbolic and Quantitative Approaches to**

Reasoning and Uncertainty Michael Clarke,Rudolf Kruse,Serafin Moral,1993-10-20 In recent years it has become apparent that an important part of the theory of artificial intelligence is concerned with reasoning on the basis of uncertain incomplete or inconsistent information A variety of formalisms have been developed including nonmonotonic logic fuzzy sets possibility theory belief functions and dynamic models of reasoning such as belief revision and Bayesian networks Several European research projects have been formed in the area and the first European conference was held in 1991 This volume contains the papers accepted for presentation at ECSQARU 93 the European Conference on Symbolicand Quantitative Approaches to Reasoning and Uncertainty held at the University of Granada Spain November 8 10 1993   *Nonmonotonic and Inductive Logic* Gerhard Brewka,1993 This proceedings volume contains a selection of revised and extended papers presented at the Second International Workshop on Nonmonotonic and InductiveLogic NIL 91 which took place at Reinhardsbrunn Castle December 2 6 1991 The volume opens with an extended version of a tutorial on nonmonotonic logic by G Brewka J Dix and K Konolige Fifteen selected papers follow on a variety of topics The majority of papers belong either to the area of nonmonotonic reasoning or to the field of inductive inference but some papers integrate research from both areas The first workshop in this series was held at the University of Karlsruhe in December 1990 and its proceedings were published as Lecture Notes in Artificial Intelligence Volume 543 The series of workshops was made possible by financial support from Volkswagen Stiftung Hannover This workshop was also supported by IBM Deutschland GmbH and Siemens AG

Nonmonotonic Reasoning Gerhard Brewka,Victor W. Marek,Miroslaw Truszczynski,2011 The publication of the seminal special issue on nonmonotonic logics by the Artificial Intelligence Journal in 1980 resulted in a new area of research in knowledge representation and changed the mainstream paradigm of logic that originated in antiquity It led to discoveries of connections between logic knowledge representation and computation and attracted not only computer scientists but also logicians mathematicians and philosophers Nonmonotonic reasoning concerns situations when information is incomplete or uncertain Thus conclusions drawn lack iron clad certainty that comes with classical logic reasoning New information even if the original one is retained may change conclusions Formal ways to capture mechanisms involved in nonmonotonic reasoning and to exploit them for computation as in the answer set programming paradigm are at the heart of this research area The conference NonMon 30 Thirty Years of Nonmonotonic Reasoning held in Lexington KY USA October 22 25 2010 aimed to sum up the experience of the first 30 years of nonmonotonic logics and to map paths into the future It comprised eighteen invited talks and several technical presentations The present volume consists of the texts based on twelve of the invited presentations These papers offer unique insights into the key questions that have been driving the development of nonmonotonic reasoning and suggest problems worthy of consideration in the future They paint the picture of the field that has a well established tradition and remains vibrant and relevant to long term goals of artificial intelligence

Nonmonotonic and Inductive Logic Jürgen Dix,Klaus P. Jantke,Peter H. Schmitt,1991 This proceedings volume contains

revised and reviewed papers based on talks presented at the first International Workshop on Nonmonotonic and Inductive Logic held in Karlsruhe December 1990 The workshop was supported by the Volkswagen Stiftung Hannover and provided a forum for researchers from the two fields to communicate and find areas of cooperation The papersare organized into sections on Nonmonotonicity in logic programs Axiomatic approach to nonmonotonic reasoning Inductive inference Autoepistemic logic Belief updates The bulk of the papers are devoted to nonmonotonic logic and provide an up to date view of the current state of research presented by leading experts in the field A novelty in the contributions from the area of inductive logic is the analysis of nonmonotonicity in the theory of inductive learning PUBLISHER S WEBSITE   On the Complexity of Fragments of Nonmonotonic Logics Michael Thomas,2010-11-29 Nonmonotonic reasoning is one of the most important tasks in the area of knowledge representation and reasoning Several logics have been developed to formalize nonmonotonic reasoning In this thesis we consider three well known logics that facilitate nonmonotonic reasoning by different means default logic autoepistemic logic and circumscription We study the computational complexity of consistency reasoning and counting problems for fragments of these logics obtained by restricting the available Boolean connectives as well as the possibility to translate between these fragments For this we generalize the logics to allow for arbitrary connectives rather than the Boolean standard base and study the complexity of the problems and possibility of translations for all finite sets of allowed Boolean connectives Our results show that in all cases the complexity of the problems does not depend on the particular set B of available connectives but on the set of functions expressible by projections and arbitrary compositions from B We obtain polytomous complexity classifications that is into a finite number of complexity degrees for all decision problems studied herein ranging from completeness for classes in the second level of the polynomial hierarchy down to membership in AC0 Furthermore the counting problems are with one interesting exception shown to be trichotomous with complexity degrees spanning the first three levels of the counting hierarchy To the best of our knowledge the counting complexity of default logic is addressed here for the first time Finally we consider translations between fragments of these logics that leave the set of propositional consequences of the input invariant We show which fragments of default logic autoepistemic logic and circumscription can under the chosen notion of translations be embedded into fragments of the other two logics We complete this picture by showing that in almost all cases in which no translation is given no translation preserving the set of propositional consequences may exist unless the polynomial hierarchy collapses

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