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Nonmonotonic and Inductive Logic

Second International Workshop Reinhardsbrunn Castle, Germany December 2-6, 1991 Proceedings

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Preface

This proceedings volume contains a selection of revised and extended papers presented at the Second International Workshop on Nonmonotonic and Inductive Logic, NIL'91, which took place at Reinhardsbrunn Castle, December 2-6, 1991. The first workshop was held at the University of Karlsruhe in December 1990. Its proceedings were published as Lecture Notes in Artificial Intelligence 543.

This series of workshops was made possible by financial support from Volkswagen Stiftung, Hannover. The application for funding was made within the framework of a special program of the Volkswagen Stiftung which promoted cooperation between the Federal Republic of Germany and what was then the German Democratic Republic. The dramatic events of the past years have had a major impact on this program. The workshops have turned into international meetings, though they still retain some emphasis on providing an opportunity for researchers from unified Germany to meet each other.

Besides the major funding by the Volkswagen Stiftung we also acknowledge support from IBM Deutschland GmbH and Siemens AG; their contributions helped give us a necessary flexibility in organising the workshop.

Besides the majority of papers belonging either to the area of nonmonotonic reasoning or to the field of inductive inference, both workshop programs included some papers integrating research from both areas. NIL'91, the second workshop in the series, was distinguished by two tutorials on the main topics of the workshop series held on the first day of the meeting in parallel sessions. R. Wiehagen presented the tutorial on inductive inference, whereas G. Brewka, J. Dix, and K. Konolige delivered the tutorial on nonmonotonic logic. This proceedings volume is introduced with an extended version of the tutorial on nonmonotonic logic by G. Brewka, J. Dix, and K. Konolige. The feedback we have received from the workshop participants suggests that they found it a stimulating five days in general, and two fruitful and instructive tutorials in particular. Who could ask for more?

We gratefully acknowledge the work by an international program committee including S. Arikawa, G. Brewka, K. P. Jantke, K. Konolige, D. Lehmann, D. Makinson, P. H. Schmitt, and R. Wiehagen. As always, behind the scenes, a number of people contributed to the success of the conference. We should like to thank the organising committee headed by S. Schönherr and including V. Gaida and E. Schneider.

November 1992

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 H. Wolter
 R. Wiehagen
 T. Zeugmann

VIII

V. Wiktor Marek, Miroslaw Truszczynski	270
Retrieval in Case-Based Reasoning Using Preferred Subtheories Michael Mehl	284
Interactive Synthesis of Process Flowcharts Yuji Takada	298
Probabilistic Inference of Approximations Juris Viksna	323

Table of Contents

Tutorials

A Tutorial on Nonmonotonic Reasoning	1
Gerd Brewka, Jürgen Dix, Kurt Konolige	

Selected Papers

On the Sample Complexity of Various Learning Strategies in the Probabilistic PAC Learning Paradigms Naoki Abe	89
More About Learning Elementary Formal Systems Setsuo Arikawa, Takeshi Shinohara, Satoru Miyano, Ayumi Shinohara	107
A Polynomial Time Algorithm for Finding Finite Unions of Tree Pattern Languages Hiroki Arimura, Takeshi Shinohara, Setsuko Otsuki	118
Towards Efficient Inductive Synthesis: Rapid Construction of Local Regularities Janis Barzdins, Guntis Barzdins	132
Deductive Generalization in a Default Logic Setting Ph. Besnard, E. Grégoire	141
Deduction with Supernormal Defaults Stefan Brass	153
Multi-Agent Learning: Theoretical and Empirical Studies Robert Daley	175
Predicate Synthesis from Formal Specifications: Using Mathematical Induction for Finding the Preconditions of Theorems Marta Franova, Yves Kodratoff	184
Dual Types of Hypotheses in Inductive Inference Rusins Freivalds, Efim B. Kinber, Rolf Wiehagen	209
All I Know About Tweety Gerhard Lakemeyer	241
Monotonic Versus Nonmonotonic Language Learning Steffer Lange, Thomas Zeugmann	254

Normai Form Results for Default Logic V. Wiktor Marek, Miroslaw Truszczynski	270
Retrieval in Case-Based Reasoning Using Preferred Subtheories Michael Mehl	284
Interactive Synthesis of Process Flowcharts Yuji Takada	298
Probabilistic Inference of Approximations Juris Viksna	323

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A TUTORIAL ON NONMONOTONIC REASONING

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Abstract

Nonmonotonic reasoning, in its broadest sense, is reasoning to conclusions on the basis of incomplete information. Given more information, we are prepared to retract previously drawn inferences. To exhibit the classic example: if all we know about Tweety is that he is a bird, then we plausibly conclude that he can fly; on learning that Tweety is a penguin, we withdraw that conclusion. We call this reasoning nonmonotonic because the set of plausible conclusions does not grow monotonically with increasing information.

As Tweety shows, commonsense reasoning has a nonmonotonic component, and it has been argued that almost all commonsense inferences are of this sort. The attempt to formalize nonmonotonic reasoning so that computer programs could use it as part of their reasoning repertoire was begun by John McCarthy in the 1970's, and the early 1980's saw the development of the major nonmonotonic families: circumscription, default logic, and modal nonmonotonic logics. At the same time, proof methods that were clearly nonmonotonic were also being developed: the so-called Truth Maintenance Systems, and negation-as-failure in logic programming and deductive databases.

From the end of the 1980's to the present there has been an explosion in research in nonmonotonic reasoning. We now understand much better the properties of the major formalisms from a metatheoretic point of view, the relationships among the formalisms, and their connection to independently-developed proof methods. The goal of this monograph is to make this understanding more accessible. For those outside the area, the quantity and technical depth of the material can be a formidable barrier to understanding and applying nonmonotonic methods. For those actively pursuing research, it is often useful to have a concise guide to the major formalisms and their interrelationships. We intend this monograph to serve both purposes. We have tried to present the formalisms as simply and concisely as possible, stressing the connections among them and unresolved issues for future research.

Contents

C	ontei	uts	3
Li	st of	Figures	5
Li	st of	Tables	6
1	Inti	roduction	7
2	Nor	nnonotonic Inference Relations	13
	2.1	Structural properties	13
	2.2	Logical connectives	14
	2.3	Classifying nonmonotonic formalisms	15
3	Mo	del preference logics	17
	3.1	Closed world assumption (CWA)	18
	3.2	Circumscription	18
		3.2.1 Parallel predicate circumscription	19
		3.2.2 Abnormality theories	21
		3.2.3 Prioritized circumscription	21
	3.3	Model preference logics	22
4	Con	nsistency-Based Logics	24
	4.1	Default Logic	25
		4.1.1 Basic Definitions and Properties	25
	4.2	Modal Nonmonotonic Logics	29
	4.3	Maximal Consistency Logics	32
	4.4	Implementations	34
		4.4.1 TMS and Nonmonotonic Process Systems	35
		4.4.2 A TMS-Based Default Logic Prover	37
5	Abo	luction	40
	5.1	Abduction in Al	40
	5.2	Logic-based systems: formulation	41
	5.3	Assumption-based Truth Maintenance	42
		5.3.1 ATMS definition and properties	43

/

Bi	bliog	graphy		72
	0.9	Conclu		(2
	<i>e</i> 5	6.4.4 Canala	CIRC and AEL _{ef} versus WFS	72
		6.4.3	Default and Autoepistemic Logic versus STABLE	70
		6.4.2	Circumscription versus M_p^{supp}	70
		6.4.1	CWA versus Negation-as-Finite-Failure	70
	6.4	Relati	ons between NMR and LP	69
		6.3.7	Classifying NMR-Semantics	67
		6.3.6	Disjunctive Programs	64
		5.3.5	Other Semantics	64
		6.3.4	WFS: The Wellfounded Semantics	63
		6.3.3	STABLE: The Stable Semantics	62
		6.3.2	M_P^{supp} : Supported Semantics for Stratified Programs	60
		6.3.1	NMR-Intuition Compared with LP-Intuition	59
	6.3	Nonm	onotonic Reasoning Semantics	59
		6.2.2	Programs with Negation	55
		6.2.1	Definite Programs	52
	6.2	Logic	Programming Semantics	51
		6.1.1	Notation and Terminology	50
	6.1	Introd	luction	48
6	Sen	antics	for Logic Programs with Negation	48
		3.4.2	Resolution algorithms	46
		5.4.1	Clause Maintenance System	45
	5.4	Abdue	ction in first-order theories	44
	E 2	a 2. de -	aking in Kunk and m Alternat	

Bibliography

List of Tables

4.1	Some default theories and	their extensions	 27

List of Figures

1.1	An Overview	11
5.1	An ATMS Diagram	43
5.2	An example for an ATMS	43
6.1	Important (Partial) Lattices of Truth-Values	51
6.2	An Infinite SLD-Tree	53
6.3	The Floundering-Problem	56
6.4	Semantics for Normal Programs	65
6.5	Classes of Programs	66
5.6	Semantics for Disjunctive Programs	69

Chapter 1 Introduction

This monograph is the outgrowth of a tutorial given at the Nonmonotonic and Inductive Logic (NIL) conference held at Friedrichroda, Germany in December of 1991. Its purpose is to give a technical overview of the field of nonmonotonic reasoning. In the past few years this field has grown tremendously, and there is a need for a broad overview sketching the basic ideas, and also giving some of the technical background necessary for understanding them. Of course, it would be impossible to give detailed accounts of even the major formalisms and their application domains, so instead we will present short overviews of the most important concepts, point out their relationships, and recount the interesting issues that are the focus of current research. An extended version of this tutorial will be available as an CSLI report.

Nonmonotonic reasoning, as a form of reasoning, contrasts with standard deductive reasoning in the following way. Suppose we know that all men are mortal, and that Socrates is a man. Then it follows by simple syllogistic reasoning that Socrates is mortal. Further, nothing we can add to our knowledge will change that conclusion, given that we still hold the premises. Deductive reasoning within a theory is "local" in the sense that, having derived a conclusion from premises, we need not worry about any other sentences in the theory. To use the technical term, deductive reasoning is monotonic:

If
$$A \vdash p$$
, then $A, B \vdash p$. (1.1)

Obviously, nonmonotonic reasoning does not share this property. Why would we ever want a logic that is nonmonotonic? Historically, the need for nonmonotonic reasoning was identified in the course of trying to solve knowledge representation problems in several application areas of Artificial Intelligence.

Databases, puzzles

In developing a database of information, say about airline flights, we usually just put in the positive facts that exist, e.g., "there is a flight from Boston to NY on United at 10:20am, March 22, 1992." The unstated assumption is that the database contains all relevant facts, so that if a flight is not listed in the database, it does not exist. Obviously, it is impossible to put all the negative facts into the database: "There is no flight from Boston to NY at 10:21am, March 22, 1992," and so on. It is also inconvenient to state the negative information using first-order axioms, since they must be changed every time the database is updated with new information. The solution, originated by Reiter [Rei78], is to formalize the assumption that the database contains all relevant facts: the Closed World Assumption, or CWA.

A second knowledge representation problem was noted by McCarthy [McC80] in formalizing various puzzles like the Missionaries and Cannibals problem:

Three missionaries and three cannibals come to a river. A rowboat that seats two is available. If the cannibals ever outnumber the missionaries on either bank of the river, the missionaries will be eaten. How shall they cross the river?

As was the case with databases, it is easy to state positive facts, such as "the boat can carry at most two people at a time across the river," but more difficult to state negative assumptions that are implicit in the puzzle, such as "the only way across the river is by the boat." McCarthy proposed a formal solution called circumscription for dealing with this and other types of unstated assumptions limiting objects and relationships to those explicitly stated in the puzzle.

In fact the CWA and circumscription have much in common, since they both work on the principle of preferring interpretations (of the database, of the puzzle) in which positive facts are minimized. The idea of preferring certain interpretations of a theory (in the case of the CWA and circumscription, ones with minimal predicate extensions) leads to one general class of nonmonotonic formalisms, called *model* preference logics.

Defaults

Another type of representational problem occurs in commonsense reasoning. Usually we have just partial information about any given situation, and it helps to make assumptions about how things normally are, in order to carry out further reasoning. For example, if we learn that someone is a doctor, we usually assume that he (or, not to be too presumptive, she) is over 25 years old, makes a good salary, etc. Without such presumptions, it would be almost impossible to carry out the simplest commonsense reasoning tasks. Of course, defaults are presumptive precisely because they could be wrong, and if we learn of our doctor that he (to be specific) is Doogie Howser, an underage overachiever, we have to withdraw conclusion that he is over 25 years old. Reasoning with defaults is nonmonotonic because learning more information may force us to retract a conclusion previously drawn.

To draw on terms from the philosophical literature, a default is a prima facie justification for its conclusion. This justification is defeasible: an explicit fact that contradicts the conclusion will nullify the justification. Any proposition that, if believed, will nullify a default, is called a defeater of the default. Pollock [Pol75] has analyzed defaults from this perspective, and drawn attention to a basic difference between two kinds of defeaters, which he labels Type I and Type II. A Type I defeater outright contradicts a default. If we have access to our fictional doctor's salary records, and discover that he earns a low salary, then the presumption of a high salary is contradicted and defeated.