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EDITORS

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***Many-Dimensional  
Modal Logics:  
Theory and  
Applications***

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ELSEVIER

# Many Dimensional Modal Logics

**Yde Venema**



## **Many Dimensional Modal Logics:**

**Multi-Dimensional Modal Logic** Maarten Marx, Yde Venema, 2012-12-06 Modal Logic is a branch of logic with applications in many related disciplines such as computer science philosophy linguistics and artificial intelligence Over the last twenty years in all of these neighbouring fields modal systems have been developed that we call multi dimensional Our definition of multi dimensionality in modal logic is a technical one we call a modal formalism multi dimensional if in its intended semantics the universe of a model consists of states that are tuples over some more basic set This book treats such multi dimensional modal logics in a uniform way linking their mathematical theory to the research tradition in algebraic logic We will define and discuss a number of systems in detail focusing on such aspects as expressiveness definability axiomatics decidability and interpolation Although the book will be mathematical in spirit we take care to give motivations from the disciplines mentioned earlier on

**Many-Dimensional Modal Logics: Theory and Applications** A. Kurucz, F. Wolter, M. Zakharyashev, Dov M. Gabbay, 2003-10-21 Modal logics originally conceived in philosophy have recently found many applications in computer science artificial intelligence the foundations of mathematics linguistics and other disciplines Celebrated for their good computational behaviour modal logics are used as effective formalisms for talking about time space knowledge beliefs actions obligations provability etc However the nice computational properties can drastically change if we combine some of these formalisms into a many dimensional system say to reason about knowledge bases developing in time or moving objects To study the computational behaviour of many dimensional modal logics is the main aim of this book On the one hand it is concerned with providing a solid mathematical foundation for this discipline while on the other hand it shows that many seemingly different applied many dimensional systems e g multi agent systems description logics with epistemic temporal and dynamic operators spatio temporal logics etc fit in perfectly with this theoretical framework and so their computational behaviour can be analyzed using the developed machinery We start with concrete examples of applied one and many dimensional modal logics such as temporal epistemic dynamic description spatial logics and various combinations of these Then we develop a mathematical theory for handling a spectrum of abstract combinations of modal logics fusions and products of modal logics fragments of first order modal and temporal logics focusing on three major problems decidability axiomatizability and computational complexity Besides the standard methods of modal logic the technical toolkit includes the method of quasimodels mosaics tilings reductions to monadic second order logic algebraic logic techniques Finally we apply the developed machinery and obtained results to three case studies from the field of knowledge representation and reasoning temporal epistemic logics for reasoning about multi agent systems modalized description logics for dynamic ontologies and spatio temporal logics The genre of the book can be defined as a research monograph It brings the reader to the front line of current research in the field by showing both recent achievements and directions of future investigations in particular multiple open problems On the other hand well known results from modal and first order logic are

formulated without proofs and supplied with references to accessible sources The intended audience of this book is logicians as well as those researchers who use logic in computer science and artificial intelligence More specific application areas are e g knowledge representation and reasoning in particular terminological temporal and spatial reasoning or reasoning about agents And we also believe that researchers from certain other disciplines say temporal and spatial databases or geographical information systems will benefit from this book as well Key Features Integrated approach to modern modal and temporal logics and their applications in artificial intelligence and computer science Written by internationally leading researchers in the field of pure and applied logic Combines mathematical theory of modal logic and applications in artificial intelligence and computer science Numerous open problems for further research Well illustrated with pictures and tables

Many-dimensional Modal Logics Dov M. Gabbay, 2003 Modal logics originally conceived in philosophy have recently found many applications in computer science artificial intelligence the foundations of mathematics linguistics and other disciplines Celebrated for their good computational behaviour modal logics are used as effective formalisms for talking about time space knowledge beliefs actions obligations provability etc However the nice computational properties can drastically change if we combine some of these formalisms into a many dimensional system say to reason about knowledge bases developing in time or moving objects To study the computational behaviour of many dimensional modal logics is the main aim of this book On the one hand it is concerned with providing a solid mathematical foundation for this discipline while on the other hand it shows that many seemingly different applied many dimensional systems e g multi agent systems description logics with epistemic temporal and dynamic operators spatio temporal logics etc fit in perfectly with this theoretical framework and so their computational behaviour can be analyzed using the developed machinery We start with concrete examples of applied one and many dimensional modal logics such as temporal epistemic dynamic description spatial logics and various combinations of these Then we develop a mathematical theory for handling a spectrum of abstract combinations of modal logics fusions and products of modal logics fragments of first order modal and temporal logics focusing on three major problems decidability axiomatizability and computational complexity Besides the standard methods of modal logic the technical toolkit includes the method of quasimodels mosaics tilings reductions to monadic second order logic algebraic logic techniques Finally we apply the developed machinery and obtained results to three case studies from the field of knowledge representation and reasoning temporal epistemic logics for reasoning about multi agent systems modalized description logics for dynamic ontologies and spatio temporal logics The genre of the book can be defined as a research monograph It brings the reader to the front line of current research in the field by showing both recent achievements and directions of future investigations in particular multiple open problems On the other hand well known results from modal and first order logic are formulated without proofs and supplied with references to accessible sources The intended audience of this book is logicians as well as those researchers who use logic in computer science and artificial intelligence More specific application areas are

e.g. knowledge representation and reasoning in particular terminological temporal and spatial reasoning or reasoning about agents And we also believe that researchers from certain other disciplines say temporal and spatial databases or geographical information systems will benefit from this book as well Key Features Integrated approach to modern modal and temporal logics and their applications in artificial intelligence and computer science Written by internationally leading researchers in the field of pure and applied logic Combines mathematical theory of modal logic and applications in artificial intelligence and computer science Numerous open problems for further research Well illustrated with pictures and tables

*Many-dimensional Modal Logic* Yde Venema, 1991      *Many-dimensional Modal Logic* Yde Venema, 1989      *Advances In Modal Logic, Volume 3* Maarten De Rijke, Heinrich Wansing, Frank Wolter, Michael Zakharyashev, 2002-09-24 *Advances in Modal Logic* is a unique forum for presenting the latest results and new directions of research in modal logic The topics dealt with are of interdisciplinary interest and range from mathematical computational and philosophical problems to applications in knowledge representation and formal linguistics Volume 3 presents substantial advances in the relational model theory and the algorithmic treatment of modal logics It contains invited and contributed papers from the third conference on *Advances in Modal Logic* held at the University of Leipzig Germany in October 2000 It includes papers on dynamic logic description logic hybrid logic epistemic logic combinations of modal logics tense logic action logic provability logic and modal predicate logic      *Advances in Modal Logic* Frank Wolter, 2002 *Advances in Modal Logic* is a unique forum for presenting the latest results and new directions of research in modal logic The topics dealt with are of interdisciplinary interest and range from mathematical computational and philosophical problems to applications in knowledge representation and formal linguistics Volume 3 presents substantial advances in the relational model theory and the algorithmic treatment of modal logics It contains invited and contributed papers from the third conference on *OC Advances in Modal Logic* held at the University of Leipzig Germany in October 2000 It includes papers on dynamic logic description logic hybrid logic epistemic logic combinations of modal logics tense logic action logic provability logic and modal predicate logic      *Deontic Logic in Computer Science* Ron van der Meyden, Leendert van der Torre, 2008-07-14 This volume presents the papers contributed to EON 2008 the 9th International Conference on Deontic Logic in Computer Science held in Luxembourg July 16-18 2008 This biennial conference series is designed to promote international cooperation amongst scholars who are interested in deontic logic and its use in computer science The scope of the conference is interdisciplinary and includes research that links the formal logical study of normative concepts and normative systems with computer science artificial intelligence philosophy organization theory and law The EON website <http://www.deonticlogic.org> contains links to previous conferences and their papers This history reveals a vibrant interdisciplinary research program Papers for these conferences might address such general themes as the development of formal systems of deontic logic and related areas of logic such as logics of action and agency or the formal analysis of all sorts of normative concepts such as the notions of rule role regulation authority power

rights responsibility etc or the formal representation of legal knowledge They might also be concerned with applications such as the formal specification of native multiagent systems the specification of systems for the management of bureaucratic processes in public or private administration or the specification of database integrity constraints or computer security protocols and more Of particular interest is the interaction between computer systems and their users

*Cylindric-like Algebras and Algebraic Logic* Hajnal Andréka, Miklós Ferenczi, István Németi, 2014-01-27 Algebraic logic is a subject in the interface between logic algebra and geometry it has strong connections with category theory and combinatorics Tarski's quest for finding structure in logic leads to cylindric like algebras as studied in this book they are among the main players in Tarskian algebraic logic Cylindric algebra theory can be viewed in many ways as an algebraic form of definability theory as a study of higher dimensional relations as an enrichment of Boolean Algebra theory or as logic in geometric form cylindric in the name refers to geometric aspects Cylindric like algebras have a wide range of applications in e.g natural language theory data base theory stochastics and even in relativity theory The present volume consisting of 18 survey papers intends to give an overview of the main achievements and new research directions in the past 30 years since the publication of the Henkin Monk Tarski monographs It is dedicated to the memory of Leon Henkin

Logics in Artificial Intelligence Sarah Gaggl, Maria Vanina Martinez, Magdalena Ortiz, 2023-09-23 This book constitutes proceedings of the 18th European Conference on Logics in Artificial Intelligence JELIA 2023 held in Dresden Germany in September 2023 The 41 full papers and 11 short papers included in this volume were carefully reviewed and selected from 111 submissions The accepted papers span a number of areas within Logics in AI including argumentation belief revision reasoning about actions causality and change constraint satisfaction description logics and ontological reasoning non classical logics and logic programming answer set programming

**Computational Logic in Multi-Agent Systems** Jürgen Dix, João Leite, Guido Governatori, Wojtek Jamroga, 2010-08-05 These are the proceedings of the 11th International Workshop on Computational Logic in Multi Agent Systems CLIMA XI held during August 16 17 in Lisbon collocated with the 19th European Conference on Artificial Intelligence ECAI 2010 Multi agent systems are communities of problem solving entities that can perceive and act upon their environment in order to achieve both their individual goals and their joint goals The work on such systems integrates many technologies and concepts from artificial intelligence and other areas of computing as well as other disciplines Over recent years the agent paradigm gained popularity due to its applicability to a full spectrum of domains such as search engines recommendation systems educational support e procurement simulation and routing electronic commerce and trade etc Computational logic provides a well defined general and rigorous framework for studying the syntax semantics and procedures for the various tasks in individual agents as well as the interaction between and integration among agents in multi agent systems It also provides tools techniques and standards for implementations and environments for linking specifications to implementations and for the verification of properties of individual agents multi agent systems and their implementations The

purpose of the CLIMA workshops is to provide a forum for discussing techniques based on computational logic for representing programming and reasoning about agents and multi agent systems in a formal way Former CLIMA editions have been conducted in conjunction with other Computational Logic and AI events such as CL in 2000 ICLP in 2001 and 2007 FLoC in 2002 LPNMR and AI Math in 2004 JELIA in 2004 and 2008 and MATES in 2009 In 2005 CLIMA was not associated with any major event

**Agent and Multi-agent Technology for Internet and Enterprise Systems** Anne Hakansson, Ronald Hartung, Ngoc Thanh Nguyen, 2010-06-17 Research in multi agent systems offers a promising technology for problems with networks online trading and negotiations but also social structures and communication This is a book on agent and multi agent technology for internet and enterprise systems The book is a pioneer in the combination of the fields and is based on the concept of developing a platform to share ideas and presents research in technology in the field and application to real problems The chapters range over both applications illustrating the possible uses of agents in an enterprise domain and design and analytic methods needed to provide the solid foundation required for practical systems

**Handbook of Modal Logic** Patrick Blackburn, Johan F.A.K. van Benthem, Frank Wolter, 2006-11-03 The Handbook of Modal Logic contains 20 articles which collectively introduce contemporary modal logic survey current research and indicate the way in which the field is developing The articles survey the field from a wide variety of perspectives the underlying theory is explored in depth modern computational approaches are treated and six major applications areas of modal logic in Mathematics Computer Science Artificial Intelligence Linguistics Game Theory and Philosophy are surveyed The book contains both well written expository articles suitable for beginners approaching the subject for the first time and advanced articles which will help those already familiar with the field to deepen their expertise Please visit [http://people.uleth.ca/~woods/RedSeriesPromo\\_WP\\_PubSLPR.html](http://people.uleth.ca/~woods/RedSeriesPromo_WP_PubSLPR.html) Compact modal logic reference Computational approaches fully discussed Contemporary applications of modal logic covered in depth

**Finite Model Theory and Its Applications** Erich Grädel, Phokion G. Kolaitis, Leonid Libkin, Maarten Marx, Joel Spencer, Moshe Y. Vardi, Yde Venema, Scott Weinstein, 2007-04-24 Finite model theory as understood here is an area of mathematical logic that has developed in close connection with applications to computer science in particular the theory of computational complexity and database theory One of the fundamental insights of mathematical logic is that our understanding of mathematical phenomena is enriched by elevating the languages we use to describe mathematical structures to objects of explicit study If mathematics is the science of patterns then the media through which we discern patterns as well as the structures in which we discern them command our attention It is this aspect of logic which is most prominent in model theory the branch of mathematical logic which deals with the relation between a formal language and its interpretations No wonder then that mathematical logic and finite model theory in particular should find manifold applications in computer science from specifying programs to querying databases computer science is rife with phenomena whose understanding requires close attention to the interaction between language and structure This volume

gives a broad overview of some central themes of finite model theory expressive power descriptive complexity and zero one laws together with selected applications to database theory and artificial intelligence especially constraint databases and constraint satisfaction problems The final chapter provides a concise modern introduction to modal logic which emphasizes the continuity in spirit and technique with finite model theory

*Algebra and Coalgebra in Computer Science* Andrea Corradini, Bartek Klin, Corina Cîrstea, 2011-08-27 This book constitutes the refereed proceedings of the 4th International Conference on Algebra and Coalgebra in Computer Science CALCO 2011 held in Winchester UK in August-September 2011 The 21 full papers presented together with 4 invited talks were carefully reviewed and selected from 41 submissions The papers report results of theoretical work on the mathematics of algebras and coalgebras the way these results can support methods and techniques for software development as well as experience with the transfer of the resulting technologies into industrial practice They cover topics in the fields of abstract models and logics specialized models and calculi algebraic and coalgebraic semantics and system specification and verification The book also includes 6 papers from the CALCO tools Workshop colocated with CALCO 2011 and dedicated to tools based on algebraic and/or coalgebraic principles

**Quantifiers, Quantifiers, and Quantifiers: Themes in Logic, Metaphysics, and Language** Alessandro Torza, 2015-07-23 This volume covers a wide range of topics that fall under the philosophy of quantifiers a philosophy that spans across multiple areas such as logic metaphysics epistemology and even the history of philosophy It discusses the import of quantifier variance in the model theory of mathematics It advances an argument for the uniqueness of quantifier meaning in terms of Evert Beth's notion of implicit definition and clarifies the oldest explicit formulation of quantifier variance the one proposed by Rudolf Carnap The volume further examines what it means that a quantifier can have multiple meanings and addresses how existential vagueness can induce vagueness in our modal notions Finally the book explores the role played by quantifiers with respect to various kinds of semantic paradoxes the logicity issue ontological commitment and the behavior of quantifiers in intensional contexts

*Handbook of Philosophical Logic* Dov M. Gabbay, Franz Guenther, 2013-06-29 It is with great pleasure that we are presenting to the community the second edition of this extraordinary handbook It has been over 15 years since the publication of the first edition and there have been great changes in the landscape of philosophical logic since then The first edition has proved invaluable to generations of students and researchers in formal philosophy and language as well as to consumers of logic in many applied areas The main logic article in the Encyclopaedia Britannica 1999 has described the first edition as the best starting point for exploring any of the topics in logic We are confident that the second edition will prove to be just as good The first edition was the second handbook published for the logic community It followed the North Holland one volume Handbook of Mathematical Logic published in 1977 edited by the late Jon Barwise The four volume Handbook of Philosophical Logic published 1983-1989 came at a fortunate temporal junction at the evolution of logic This was the time when logic was gaining ground in computer science



and artificial intelligence circles These areas were under increasing commercial pressure to provide devices which help and or replace the human in his daily activity This pressure required the use of logic in the modelling of human activity and organisation on the one hand and to provide the theoretical basis for the computer program constructs on the other

*Neural-Symbolic Cognitive Reasoning* Artur S. D'Avila Garcez, Luís C. Lamb, Dov M. Gabbay, 2009 This book explores why regarding practical reasoning humans are sometimes still faster than artificial intelligence systems It is the first to offer a self contained presentation of neural network models for many computer science logics

### **Logic and Its Applications**

Kamal Lodaya, 2012-12-22 Edited in collaboration with FoLLI the Association of Logic Language and Information this book constitutes the refereed proceedings of the 5th Indian Conference on Logic and Its Applications ICLA 2013 held in Chennai India in January 2013 The 15 revised full papers presented together with 7 invited talks were carefully reviewed and selected from numerous submissions The papers cover the topics related to pure and applied logic foundations and philosophy of mathematics and the sciences set theory model theory proof theory areas of theoretical computer science artificial intelligence and other disciplines which are of direct interest to mathematical and philosophical logic

Logical Foundations of Computer Science Sergei Artemov, Anil Nerode, 2007-06-30 This book constitutes the refereed proceedings of the International Symposium on Logical Foundations of Computer Science LFCS 2007 held in New York NY USA in June 2007 The volume presents 36 revised refereed papers that address all current aspects of logic in computer science

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