PHIL 858P - Modal Logic

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Semester:	Spring 2019
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Class Times:	Mondays 2:00pm - 4:30pm
Class Location:	Skinner 1116

Course Description

This course is an introduction to mathematical modal logic and its applications in philosophy, computer science, linguistics, and economics. The course will start with a rigorous development of propositional modal logic: the basic language, interpretation in relational structures, axiom systems, proofs, and validity. We will then discuss the metatheory of modal logic: completeness, incompleteness, decidability and complexity, model equivalences and expressivity results. We also consider neighborhood semantics as an alternative to relational semantics, and introduce first-order modal logic, incorporating intensional objects and first-order quantification. In the latter part of the course we examine the many variations and philosophical interpretations of the basic systems of modal logic. Topics that may be discussed include epistemic and doxastic logic, conditional logic, non-normal modal logics, logics of action and agency, multi-agent systems and common knowledge (with applications to game theory), deontic logics, logics for reasoning about counterfactuals, temporal logic, public announcement logic and dynamic epistemic logic, justification logic, and others.

Students will come away from this course with a working knowledge of modal logic and its use in philosophy, linguistics, computer science and game theory. The main objective is that students should be able to confidently apply techniques from modal logic to problems in their area of research. They should be able to apply existing modal logics where appropriate and design new logical systems when necessary, and rigorously analyze their properties.

Prerequisites

You should know basic propositional and first order logic, as well as some basic set theory, as in sets, relations, and functions—although the latter can be picked up. You could have a look at the following:

- `http://www.logicinaction.org/`: the chapters: Propositional Logic, The World According to Predicate Logic, Validity Testing, Proofs, and Appendix A: Sets, Relations and Functions
- `http://builds.openlogicproject.org/courses/boxes-and-diamonds/`: See the appendix to this book (discusses propositional logic, deductions, etc.)

We'll talk about prerequisites on the first day. I want to adapt the course to the students that show up, to make sure that everyone is in a position to follow the more advanced material.

Course materials

Central texts:

- [MLOM] *Modal Logic for Open Minds* by Johan van Benthem
- [ML] *Modal Logic* by Patrick Blackburn, Maarten de Rijke, and Yde Venema

In addition, we will use excerpts from the following texts:

- [FM] *First Order Modal Logic* by Melvin Fitting and Richard Mendelsohn
- [NBHD] *Neighborhood Semantics for Modal Logic* by Eric Pacuit

I'll also provide additional course notes and lecture slides and we will discuss some research papers.

Course work

I'll do most of the lecturing on the technical material about modal logic. All students who want credit for the course must write up solutions to problems assigned during the semester. Your solutions won't be graded, but we will discuss the answers either in class or during my office hours. You are encouraged to collaborate on the problems. In addition, students must write a short paper on a topic of their choice (I'll give lots of suggestions for paper topics). The paper can be expository, formal, or philosophical. Students will be required to give a presentation related to their paper (we'll either schedule time during a lecture or arrange a day at the end of the semester for the presentations).

Course topics

The topic list is tentative. It won't be possible to cover all of these topics, and we may want to discuss other topics.

1. Background
   (a) Propositional and First Order Logic
   (b) Sets, Relations, and Functions
2. Propositional Modal Logic
   (a) Relational structures · modal languages · models and frames
   Reading: [MLOM], ch. 2; [ML], sects. 1.1 - 1.3
   (b) Expressive power and invariance
   Reading: [MLOM], ch. 3; [ML], sects. 2.1 - 2.2
   (c) Axioms and proofs · validity and decidability
   Reading: [MLOM], chs. 4 & 5; [ML], sects. 1.5 - 1.6
   (d) Completeness
   Reading: [ML], sects. 4.1 - 4.4; [MLOM], chs. 5 & 8
   (e) Frame definability
   Reading: [MLOM], ch. 9; sects. 3.1 - 3.3
   (f) Standard translation and expressive power
   Reading: [MLOM], ch. 7, [ML], sect. 2.4
3. Quantified Modal Logic
   (a) Syntax and semantics (constant domains)
   Reading: [FM], sects. 4.1 - 4.6; S. Lindström and K. Segerberg, Modal logic and philosophy, 2007, sect. 1.
   (b) Variable domain models
   Reading: [FM], sects. 4.7-4.8; [MLOM], sects. 11.1 - 11.2.
   (c) First order modal logics
   Reading: [FM], sects. 4.9, 6.1-6.3; [MLOM], sects. 11.3 -11.4.
   (d) First-order intensional logic
   Reading: M. Fitting, On Height and Happiness, in Rohit Parikh on Logic, Language and Society, pp. 235 - 258, 2017; M. Fitting, First Order Intensional Logic, Annals of Pure and Applied Logic, 2004
   (e) Propositional quantifiers
   Reading: W. Holliday and T. Litak, One Modal Logic to Rule Them All, proceedings of AiML; F. Belardinelli and W. van der Hoek, A Semantical Analysis of Second-Order Propositional Modal Logic, proceedings of AAAI; B. ten Cate, Expressivity of second order propositional modal logic. JPL 35(2):209- 223, 2006.

4. Neighborhood semantics for modal logic

   (a) Non-normal modal logics
   Reading: [NBHD], sects. 1.2, 2.1, 2.3, 2.6

   (b) First-order neighborhood models
   Reading: [NBHD], sects. 3.2

5. Topics (Epistemic and doxastic logic)

   (a) Introduction to epistemic logic
   Reading: [MLOM], ch. 13; W. Holliday, Epistemic Logic and Epistemology (survey chapter), Handbook of Formal Philosophy, Springer.

   (b) Plausibility models
   Reading: [MLOM], ch. 13; A. Baltag and S. Smets, A Qualitative Theory of Dynamic Interactive Belief Revision, in 2008; O. Board. Dynamic interactive epistemology. Games and Economic Behaviour, 49, 2002.

   (c) Logics of knowledge and belief
   Reading: R. Stalnaker, On Logics of Knowledge and Belief, Philosophical Studies, 128, 2006; A. Baltag, N. Bezhanishvili, A. Ozgün, S. Smets, A Topological Approach to Full Belief, Journal of Philosophical Logic; A. Bjorndahl and A. Ozgün, Logic and Topology for Knowledge, Knowability, and Belief, TARK.

   (d) Dynamic epistemic logic
   Reading: [MLOM], ch. 14, secs. 15.1 - 15.4, 15.6 - 15.7; E. Pacuit, Dynamic Epistemic Logic II: Logics of Information Change, Philosophy Compass, 8, 2013

   (e) Topics in first-order epistemic logic
   Reading: Y. Wang, Beyond knowing that: a new generation of epistemic logics, manuscript; J. Seligman and Y. Wang, When Names Are Not Commonly Known: Epistemic Logic with Assignments; W. Holliday and J. Perry, Roles, rigidity, and quantification in epistemic logic, in: Johan van Benthem on Logic and Information Dynamics, Springer, pp. 591 - 629, 2014

   (f) Logics of knowledge, action and time
   Reading: Y. Venema, Temporal Logic, In The Blackwell Guide to Philosophical Logic, pp. 203 - 223, 2001; C. Dixon, C Nalon and R. Ramanujam, Knowledge and Time, in Handbook of Epistemic Logic; J. Horty, Agency and Deontic Logic, sects. 2.1-2.3; J. Horty and E. Pacuit, Action Types in Stit Semantics, Review of Symbolic Logic, 2017

6. Additional topics: justification logic; (dynamic) logics of evidence and belief; game logics; logics of common knowledge and common beliefs; modal μ-calculus; preference modal logics; modal logic for game theory; modal logics for social choice; logics of counterfactuals