LE/EECS 4401 3.0 Artificial Intelligence
GS/EECS 5326 3.0 Topics in Artificial Intelligence
Winter 2022

Department of Electrical Engineering & Computer Science,
York University

For additional information, see the course page on eClass!

Course Description

This is a second course in artificial intelligence that covers selected topics in this area such as: reasoning about action and planning, uncertain and fuzzy reasoning, knowledge representation, automated reasoning, non-monotonic reasoning and answer set programming, ontologies and description logic, local search methods, Markov decision processes, autonomous agents and multi-agent systems, machine learning, reasoning about beliefs and goals, and expert systems.

This Year's Theme: Knowledge-Based Systems and their Relationship to Machine Learning.

Knowledge-based systems that use symbolic representations of knowledge and automated reasoning are well established and their performance is often quite good. However it can be very costly to have experts input the knowlege that they use. Recently, given the availability of labelled training data, there has been a lot of work on using maching learning techniques to build AI applications, which often achieve with very good performance. However, this has lead to concerns about the safety of such systems and their inability to explain their behavior. Given this, there is much interest in understanding how to relate and combine knowledge-based systems techniques and maching learning methods. The course will cover a broad range of current symbolic knowledge representation and reasoning techniques, including probabilistic methods, and also discuss associated mchine learning techniques, in particular, reinforcement learning.

Instructor

Prof. Yves Lespérance
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Lectures

Tuesday and Thursday from 10:00 to 11:30 in LSB 101 (Life Sciences Building).

Instructor Office Hours

Tuesdays and Thursdays from 12:00 to 13:00.

Textbooks (Optional)

Russell, S.J. and Norvig, P., *Artificial Intelligence: A Modern Approach, 4th edition* Prentice Hall, 2020. ISBN 978-0134610993.
Authors' web site, Publisher's web site.
(If you already have the 3rd edition, you can use that instead of the 4th.)

Ronald J. Brachman and Hector J. Levesque, *Knowledge Representation and Reasoning*, Elsevier/Morgan Kaufmann 2004. ISBN 1-55860-932-6.
Publisher's web site

Prerequisites

General prerequisites; LE/EECS3401 3.00 Introduction to Artificial Intelligence and Logic Programming. You should know first-order logic. You must know either Prolog or Java, preferably both.

Evaluation

Assignments (2 @ 10% (each)	20%
Midterm Test	20%
Project Proposal	5%
Project Presentation	10%
Project Report	20%
Final Exam	25%
Total	100%

Tentative Schedule

- Week 1 (Jan 10) Introduction to AI and Knowledge Representation. Review of First-Order Logic (FOL). Expressing Knowledge in FOL.
- Week 2 (Jan 17) Reasoning in FOL. Supervised learning.
- Week 3 (Jan 24) Description Logic and Ontologies.
- Week 4 (Jan 31) Default Reasoning and Answer Set Programming (ASP).
- Week 5 (Feb 7) Reasoning about Action.
- Week 6 (Feb 14) Automated Planning.
- (Feb 21) Reading Week -- No Classes. Assignement 1 due.
- Week 7 (Feb 28) Reasoning under Uncertainty and Bayes Nets. Midterm Test.
- Week 8 (Mar 7) Reasoning under Uncertainty and Bayes Nets. Learning Probabilistic Models. Project Proposals Due.
- Week 9 (Mar 14) Sequential Decision Making Under Uncertainty (Markov Decision Processes).
- Week 10 (Mar 22) Reinforcement Learning. Assignment 2 due.
- Week 11 (Mar 28) Reinforcement Learning.
- Week 12 (Apr 4) Project Presentations.

Academic Honesty

It is important that you look at the departmental guidelines on academic honesty. You must cite all sources

that you use in answering assignment and test questions, and in your project report. You may not collaborate with others in course assignments, tests, and project unless indicated, and all collaborators must be listed.

References

Other good AI textbooks:

Poole, D. and Mackworth, A. *Artificial Intelligence, Foundations of Computational Agents, 2nd edition*, Cambridge University Press, 2017.

On First-Order Logic:

Enderton, H.B., *A Mathematical Introduction to Logic*. Academic Press, New York, 1972.

Tourlakis, G., *Mathematical Logic*. Wiley, 2008.

On knowledge representation:

Baral, C. *Knowledge representation, reasoning, and declarative problem solving*. Cambridge University Press, Cambridge/New York, 2003.

Genesereth, M.R. and Nilsson, N.J. *Logical foundations of artificial intelligence*. Morgan Kaufmann, Los Altos, CA, 1987.

Van Harmelen, F., Lifschiltz, V., and Porter, B. *Handbook of Knowledge Representation*. Elsevier, Amsterdam, 2008.

On description logic:

Baader, F., Calvanese, D., McGuiness, D., Nardi, D., Patel-Schneider, P. *The Description Logic Handbook, 2nd Edition*. Cambridge Univ. Press, Cambridge UK, 2007.

Lutz, C. Reasoning in Description Logics: Expressive Power vs. Computational Complexity, slides from Tutorial at KR 2010.

On reasoning about action:

Reiter, R., *Knowledge in Action: Logical Foundations for Specifying and Implementing Dynamical Systems,* MIT Press, 2001. York Library eCopy, Book home page.

On AI Planning:

Geffner, H. and Bonet, B. *A Concise Introduction to Models and Methods for Automated Planning*. Synthesis Lectures on Artificial Intelligence and Machine Learning. Morgan & Claypool Publishers, 2013.

Haslum, P., Lipovetzky, N., Magazzeni, D., and Muise, C. *An Introduction to the Planning Domain Definition Language*. Synthesis Lectures on Artificial Intelligence and Machine Learning. Morgan & Claypool Publishers, 2019.

Hoffmann, J. Everything you always wanted to know about planning - (but were afraid to ask). In Bach, J. and Edelkamp, S., editors, *KI 2011: Advances in Artificial Intelligence, 34th Annual German Conference*

on AI, Berlin, Germany, October 4-7, 2011. Proceedings, volume 7006 of Lecture Notes in Computer Science, pages 1â€“13. Springer, 2011.

Ghallab, M. Nau, D, and Traverso, M. *Automated Planning: Theory & Practice*, Morgan Kaufmann, 2004.

On Machine Learning:

Murphy, K.P. *Machine Learning: A Probabilistic Perspective*. Adaptive computation and machine learning. MIT Press, 2012.

Mitchell, T.M. *Machine Learning*. McGraw-Hill, 1997.

Goodfellow, I., Bengio, Y., and Courville, A. *Deep Learning*. Adaptive computation and machine learning. MIT Press, 2016.

On Reinforcement Learning:

Sutton, R. S. and Barto, A. G. *Reinforcement Learning - An Introduction*, 2nd Edition. Adaptive computation and machine learning. MIT Press, 2018.

On Prolog:

Clocksin, W.F. and Mellish, C.S., *Programming in Prolog,* (5th edition), Springer Verlag, New York, 2004.

Bratko, I. *Prolog Programming for Artificial Intelligence 4th Edition*, Pearson Education Canada, 2012.

Sterling, L.S. and Shapiro, E.Y. *The Art of Prolog, Second Edition*, MIT Press, 1994.

Running SWI-Prolog in the Prism Lab

- To **run** Prolog execute the command `pl`. To **exit** enter `<CTRL>-D` at the prompt.
- Documentation is available on the web.

Getting Prolog

- SWI-Prolog -- Windows, Linux, and Mac OS X versions of Prolog. Free software licensed under the Lesser GNU Public License. Look under downloads and IDE tools.

About Prolog

- A starting point is the Carnegie Mellon School of Computer Science Prolog repository.