جـــامـــعـــة مـحـمـد بـــن زايـــد
للـــذكـــاء الاصـــطـــنـــاعـــي
MOHAMED BIN ZAYED UNIVERSITY
OF ARTIFICIAL INTELLIGENCE

Core Courses Syllabi

ML705 - Topics in Advanced Machine Learning

Title	Topics in Advanced Machine Learning
Code	ML705
Loading	4 Credit-hours
Prerequisites	• Basics of Linear Algebra, Calculus, Probability and Statistics • Proficiency in Python • ML 701 Machine Learning or equivalent
Catalog Description	This course focuses on recent advances in machine learning and on developing skills for performing research to advance the state of the art in machine learning. This course builds upon concepts from Machine Learning (ML 701) and assumes familiarity with fundamental concepts in machine learning, optimization, and statistics. The course covers advanced topics from kernel methods, graphical models, advanced learning algorithms such as manifold learning, active learning, transfer learning, multi-task learning, and semi-supervised learning. Finally, the course overviews advances in reinforcement learning. Students will be engaged through course-work, a literature review, and projects.
Goal	This graduate course aims to inculcate a deeper understanding of the advanced machine learning methods, so the students are capable of researching, developing, and implementing these methods for solving real-world problems. This course aims to instill a deep understanding of kernel methods, graphical models, reinforcement learning and various advanced learning algorithms such active learning, manifold learning, transfer learning, multi-task learning and semi-supervised learning. Additionally, a significant goal of this course is to enhance students' teamwork skills by requiring them to participate in group projects.
Contents	This course covers three modules: **(I)** Kernel Methods and Graphical Models, **(II)** Advanced Learning Algorithms, **(III)** Reinforcement Learning
Recommended Textbooks	1. K. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012. ISBN: 0262018020 2. C. Bishop, *Pattern Recognition and Machine Learning*, Berlin: Springer-Verlag, 2006. ISBN: 0387310738
Recommended References & Supplemental Material	Relevant research papers, tech reports, and surveys for each topic, where needed, are identified in the teaching plan ahead. In addition, the following textbooks may be useful: 1. S. Shalev-Shwartz, and S. Ben-David. *Understanding Machine Learning: From Theory to Algorithms*. Cambridge University Press, 2014. ISBN: 1107057132 2. D. Barber. *Bayesian Reasoning and Machine Learning*, Cambridge University Press, 2012. ISBN: 0521518148

Teaching Week	Topics
1	**Kernel Methods and Graphical Models** **Lectures** • Kernel Methods in Machine Learning • Relevant papers and assigned reading: - T. Hofmann, B. Schölkopf, A. J. Smola, “Kernel Methods in Machine Learning,” *The Annals of Statistics*, Vol. 36, No. 3, 2008. - C. Cortes, V. N. Vapnik, "Support-vector networks,” *Machine Learning*, 20 (3): 273–297, 1995. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start **project-1** work
2	**Kernel Methods and Graphical Models** **Lecture** • Graphical Models – Representation • Reading group activity on selected papers related to **“Kernel Methods and Graphical Models”** - M. J. Wainwright, M. I. Jordan, “Graphical Models, Exponential Families, and Variational Inference,” Foundations and Trends in Machine Learning, Vol. 1, Nos. 1–2, 2008. **Lab** • Continue **project-1** work
3	**Kernel Methods and Graphical Models** **Lecture** • Graphical Models – Inference • Group discussion on the relevant papers - B. J. Frey and N. Jojic, "A comparison of algorithms for inference and learning in probabilistic graphical models," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 27, no. 9, pp. 1392-1416, Sept. 2005. **Lab** • Continue **project-1** work

Teaching Week	Topics
4	**Kernel Methods and Graphical Models** **Lecture** • Graphical Models – Learning Methods • Group discussion on the relevant papers - B. J. Frey and N. Jojic, "A comparison of algorithms for inference and learning in probabilistic graphical models," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 27, no. 9, pp. 1392-1416, Sept. 2005. **Lab** • Preparation of presentation on project-1 work • Continue **project-1** work
5	**Kernel Methods and Graphical Models** **Lecture** • Exam will be held instead of 1 scheduled lecture • Student presentations **Lab** • Complete **project-1** work and presentation
6	**Advanced Learning Algorithms** This module overviews the following: Manifold Learning, Transfer Learning, Multi-task Learning, Semi-supervised Learning, and Active Learning **Lecture** • Introduction to Manifold Learning • Discussion of papers: - L.J.P. v.d. Maaten, G.E. Hinton, "Visualizing High-Dimensional Data Using t-SNE," *Journal of Machine Learning Research* 9(Nov) :2579-2605, 2008. - J. B. Tenenbaum, V. deSilva, J. C. Langford, "A Global Geometric Framework for Nonlinear Dimensionality Reduction," *Science*, 22 Dec 2000. - C. J. C. Burges, "Dimension Reduction: A Guided Tour," Foundations and Trends in Machine Learning, Vol. 2, No. 4, 2009. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start **project-2** work

Teaching Week	Topics
7	**Advanced Learning Algorithms** **Lecture** • Introduction to Transfer and Multi-Task Learning • Reading group activity on relevant papers: - S. Ben-David, J. Blitzer, K. Crammer, A. Kulesza, F. Pereira, J. W. Vaughan, "A theory of learning from different domains," *Machine Learning*, 79: 151–175, 2010. - L. Duan, I.W. Tsang, D. Xu, "Domain Adaptation from Multiple Sources via Auxiliary Classifiers," ICML, 2009. - Y. Zhang and Q. Yang, "A Survey on Multi-Task Learning," Arxiv, 2018. **Lab** • Continue **project-2** work
8	**Advanced Learning Algorithms** **Lecture** • Introduction to Semi-supervised Learning • Discussion of relevant papers: - X. Zhu, "Semi-Supervised Learning Literature Survey," *UW Madison Tech Report*, 2008. - J. Amores, "Multiple instance classification: Review, taxonomy and comparative study," *Artificial Intelligence*, vol. 201, 2013. - N. Natarajan, I. S. Dhillon, P. Ravikumar, "Learning with Noisy Labels," *Neural Information Processing Systems*, 2013. **Lab** • Continue **project-2** work
9	**Advanced Learning Algorithms** **Lecture** • Introduction to Active Learning and Online Learning • Discussion of relevant papers: - B. Settles, "Active Learning Literature Survey," *UW Madison Tech Report*, 2010. - J. Gama, I. Žliobaitė, A. Bifet, M. Pechenizkiy, "A survey on concept drift adaptation," ACM Computing Surveys, vol. 46, April 2014. - J. Kirkpatrick *et al.*, "Overcoming catastrophic forgetting in neural networks," PNAS, 2017. **Lab** • Preparation of presentation on project-2 work • Continue project-2 work

Teaching Week	Topics
10	**Advanced Learning Algorithms** **Lecture** • Exam will be held instead of 1 scheduled lecture • Student presentations **Lab** • Complete **project-2** work and presentation
11	**Reinforcement Learning** **Lecture** • Model-Free Reinforcement Learning • Discussion of relevant papers: - C. Watkins, P. Dayan, "Q-Learning," *Machine Learning*, vol 8, 1992. - L. P. Kaelbling, M. Littman, A. Moore, "Reinforcement Learning: A Survey," *Journal of Artificial Intelligence Research*, vol. 4, 1996. **Lab** • Discussion on choosing a relevant paper to implement for the project • Start project-3 work
12	**Reinforcement Learning** **Lecture** • Reinforcement Learning Continued • Discussion of relevant papers: - V. Mnih *et al.*, "Human-level control through deep reinforcement learning," *Nature*, vol. 518. 2015. - Z. Wang *et al.*, "Dueling Network Architectures for Deep Reinforcement Learning," ICML, 2016. **Lab** • Continue **project-3** work
13	**Reinforcement Learning** **Lecture** • Policy Optimization Methods in RL • Discussion of relevant papers: - J. Peters, S. Schaal, "Reinforcement learning of motor skills with policy gradients," *Neural Networks*, vol. 21, May 2008. - R. Sutton et al., "Policy Gradient Methods for Reinforcement Learning with Function Approximation," *Neural Information Processing Systems*, 2000. **Lab** • Continue **project-3** work

Teaching Week	Topics
14	**Reinforcement Learning** **Lecture** • Model-Based Reinforcement Learning • Discussion of relevant papers: - D. Silver *et al.*, Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm, Arxiv, 2017. **Lab** • Preparation of presentation on project-3 work • Continue **project-3** work
15	**Reinforcement Learning** **Lecture** • Exam will be held instead of 1 scheduled lecture • Student presentations **Lab** • Complete **project-3** work and presentation