Shanghai Jiao Tong University

Course Syllabus

Artificial Intelligence for Business Research

Spring 2024

INSTRUCTOR: Professor Renyu (Philip) Zhang

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Office Hours: By appointment

Office Location: XXX

COURSE MEETINGS

Meeting Times:

May 8, 2:00PM-5:40PM
May 10, 6:00PM-9:05PM
May 11, 6:00PM-9:05PM
May 12, 2:00PM-5:40PM
May 15, 2:00PM-5:40PM
May 16, 6:00PM-9:05PM
May 17, 6:00PM-9:05PM
May 18, 2:00PM-5:40PM

Location: XXX

Course Website: https://github.com/rphilipzhang/AI-PhD-Antai-Su2024

Lecture Format: In person

Zoom Room: , Pass code:

Lecture Videos: The lectures will be recorded and available to the students who take this course for credit.

TEACHING ASSISTANT: Zhenkang Peng

Email: zhenkang1397@gmail.com

TUTORIALS

The TA will give two optional online tutorials, one on Python basics (May 9, 10:00am-noon) and the other on PyTorch basics (May 10, 10:00am-noon). Both tutorials will be recorded and you may choose to attend one or both based on your own needs.

COURSE DESCRIPTION

Modern machine-learning(ML)-based artificial intelligence (AI) has largely reshaped our world over the past 10 years. This Ph.D. course is designed to prepare students from a broad range of business areas (e.g., Finance, Marketing, Accounting, Management, Operations, Information Systems, Business Economics, Hotel Management etc.) for the cutting-edge research that connects AI and business. At a high-level, students taking this course will learn the following:

- Fundamental concepts/methods of machine learning (ML) and AI that are used in business research.
- How business researchers have utilized ML/AI and what managerial questions have been addressed by ML/AI in the recent decade.
- A basic taste of what the state-of-the-art AI/ML technologies can do in the ML/AI community and, potentially, in your own research field.

PREREQUISITES

The target audiences of this course are MPhil and PhD students interested in applying AI/ML to their own field of study in business. The students are expected to master the following before the beginning of this course:

- Working knowledge in calculus, linear algebra, and statistics;
- Working knowledge with Python (or my approval if the student has prior programming experience with a language other than Python, e.g., R, STATA, or MatLab);
- Basic knowledge of machine learning;
- Basic knowledge of econometrics and causal inference.

References and tutorials for the required prerequisites will be provided along the progress of this course. Please talk to me if you are unsure whether this course is suitable for you.

Learning Outcomes

The students taking this course will receive multi-faceted training in AI/ML and its application in business research. At the end of this course, you are expected to learn the following:

- Fundamental ideas and tools in AI/ML (and their limitations) that are widely used in their research fields;

- The state-of-the-art literature landscape and research norm for the interface between AI/ML and business;
- The ability to apply AI/ML techniques in your own research;
- The ability to identify new research questions in your fields that are potentially solvable by AI techniques.

The course will try to balance between the hands-on implementation of AI/ML methods and the conceptual understanding of business research frontier where AI/ML plays a critical role.

Recommended Reading: General References

The following general references should be useful regardless of what field you are in and what research topics you are working on.

- *The Elements of Statistical Learning* (2nd Edition), 2009, by Trevor Hastie, Robert Tibshirani, Jerome Friedman, https://hastie.su.domains/ElemStatLearn/.
- *Deep Learning*, 2016, by Ian Goodfellow, Yoshua Bengio and Aaron Courville, https://www.deeplearningbook.org/.
- *Dive into Deep Learning* (2nd Edition), 2023, by Aston Zhang, Zack Lipton, Mu Li, and Alex J. Smola, https://d2l.ai/.
- *Deep Learning with PyTorch*, 2020, by Eli Stevens, Luca Antiga, and Thomas Viehmann.
- *Probabilistic Machine Learning: An Introduction*, 2022, by Kevin Murphy, https://probml.github.io/pml-book/book1.html.
- *Probabilistic Machine Learning: Advanced Topics*, 2023, by Kevin Murphy, https://probml.github.io/pml-book/book2.html.
- Mullainathan, Sendhil, and Jann Spiess. 2017. Machine learning: an applied econometric approach. *Journal of Economic Perspectives* 31(2): 87-106.
- Athey, Susan, and Guido W. Imbens. 2019. *Machine learning methods that economists should know about. Annual Review of Economics* 11: 685-725.

COURSE WEBSITE/MATERIALS

Course materials, including slides, lecture notes, codes, and optional readings, will be distributed electronically through the GitHub course website.

The link to the GitHub of this course:

- https://github.com/rphilipzhang/AI-PhD-Antai-Su2024

The GitHub repository is public, so feel free to check it out often and let me know if you have any questions. I recommend you folk the repo to your own GitHub and update your folked repo regularly and frequently.

COURSEWORK and GRADING

You will form groups that do not change throughout this course and have a maximum size of two students. Please submit the group via the designated Google Sheet before 11:59pm, May 8, 2024 (Wednesday). Let me know if you need any help find a group mate. You will work with your group mate on the following:

- **Homework Problem Sets** (we will have 4 coding assignments, 2 for each half)
- **Replication Projects** (we will have 2 replication projects, 1 for each half)

At the end of this course, you will be asked to mutually evaluate your group mate's contribution towards Problem Sets and Replication Projects.

Grading: We follow the same grading practices as Shanghai Jiao Tong University, Antai College of Economics and Management. The following grades may be awarded: A, A-, B+, B, B-, C+, C, C-, D+, D, F. In general, A indicates excellent work, B indicates good work, C indicates satisfactory work, and D indicates passable work and is the lowest passing grade. F indicates failure.

- **Course Participation** ($X\%$ bonus)
- **Problem Sets** ($40\% = 20\% \times 2$)
- **Projects** (60%)

Class Participation

You are expected to actively participate in the discussions of the lecture content, homework problem sets, research paper presentations, and each others' final projects. I expect you to arrive to class on-time and be prepared, and to stay involved during class sessions. You will receive extra credits for asking good questions or providing insightful comments either during the class or in the WeChat Group.

Problem Sets

There will be 2 coding problem sets distributed for each half. All problem sets will be posted on our course GitHub, and will be due at 11:59pm, June 2, 2024. You should work with your group mate on each problem set, and submit your CoLab link on the designated Google Sheet. In principle, you can read each other's code, but you should submit the code written by yourselves (probably with the help of AI). Each problem set counts 20% of the final grade. We will grade the problem sets very generously using the following rubric:

- 20 means you have made sincere efforts to solve this problem set;

- 10 means you have made non-negligible efforts to solve this problem set;
- 0 means you have made negligible efforts to solve this problem set OR you do not submit anything.

Late assignments will not be accepted. You will receive the same grade as your group mate for each problem set.

Replication Projects

Each group will work on a replication project of your own choice from the list of papers I provide. These papers all have their replication packages available online. Please talk to me if you are interested in replicating another paper related to our course but outside the list. The papers are mostly applications of AI/ML within a business/economics context. Your job is to fully understand the paper and try to replicate its results to the greatest extent possible. Extra credits will be given if you can offer additional significant insights that are not reported in the original paper. Both projects are due at 11:59pm, June 2, 2024. You should submit (a) your CoLab link of your replication project with all the necessary code and results; and (b) a succinct report (no more than 5 pages excluding references and appendices) articulating what you have done and what you have found, with the focus on the comparison between your results and the original paper. The replication project counts 60% towards your final grade.

Here's the timeline of your final project:

- May 13, 11:59pm: Submit your choice of Replication Project 1 on Google Sheet (for those who take the first half of the course for credit).
- May 19, 11:59pm: Submit your choice of Replication Project 2 on Google Sheet (for those who take the second half of the course for credit).
- June 2, 11:59pm: Submit your CoLab links and project reports on Google Sheet.

The replication projects will be evaluated based on

- whether you understand the original paper and implement their methods correctly;
- whether you obtain reasonable results from your replication and interpret them correctly;
- whether your results are fairly compared with the original paper;
- whether your report is well written.

You will receive the same grade as your group mate for the final project.

Choose one from the following to replicate for Project 1 (1st-Half):

- Chen, Luyang, Markus Pelger, Jason Zhu (2023) Deep Learning in Asset Pricing. *Management Science* 70(2):714-750.

- Mei, Q., Xie, Y., Yuan, W., Jackson, M. O. (2024). A Turing test of whether AI chatbots are behaviorally similar to humans. *Proceedings of the National Academy of Sciences*, 121(9), e2313925121.

Choose one from the following to replicate for Project 2 (2nd-Half):

- Zhang, Mengxia and Lan Luo. 2023. Can consumer-posted photos serve as a leading indicator of restaurant survival? Evidence from Yelp. *Management Science* **69**(1): 25-50.
- Burnap, Alex , John R. Hauser, Artem Timoshenko (2023) Product Aesthetic Design: A Machine Learning Augmentation. *Marketing Science* 42(6):1029-1056.

CLASS WORK

Building AI/ML models and implementing them in a programming language is an indispensable part of learning in this course. However, I may not be able to go over the code in very detail due to the limited class time. I suggest you take your laptop to each session and open the code I distribute to you in CoLab, so as to have a better conceptual understanding of the AI/ML methods.

Classroom Norms: Cell phones and other electronic devices are a disturbance to both students and to me. All electronic devices (except laptops) must be turned off prior to the start of each class meeting.

Laptops: You are expected to bring a laptop to each class and read the related code, unless otherwise instructed. Please use it for class activities only.

Students with Disabilities: Please refer to the related support of Shanghai Jiao Tong University.

WECHAT GROUP

We will establish a WeChat group as the off-class online discussion platform for this course. All students are required to enter this group, and are encouraged to post and discuss any questions, suggestions, and/or comments about this course in the class WeChat group. Students who actively contribute to the discussions in our WeChat group may receive some extra credits in the final course grade.

ACADEMIC INTEGRITY

Integrity is critical to the learning process and to all that we do here at the Shanghai Jiao Tong University. As members of our community, all students agree to abide by the academic integrity/honesty policies of SJTU, which includes a commitment to:

- Exercise integrity in all aspects of one's academic work including, but not limited to, the preparation and completion of exams, papers and all other course requirements by not engaging in any method or means that provides an unfair advantage.
- Clearly acknowledge the work and efforts of others when submitting written work as one's own. Ideas, data, direct quotations (which should be designated with quotation marks),

paraphrasing, creative expression, or any other incorporation of the work of others should be fully referenced.

- Refrain from behaving in ways that knowingly support, assist, or in any way attempt to enable another person to engage in any violation of the Academic Honesty policies of CUHK. Our support also includes reporting any observed violations that are deemed to adversely affect the CUHK community.
- You may not submit the same work (or substantially similar work) to meet the requirements of more than one course without written consent of all instructors concerned.

COURSE EVALUATIONS

Course evaluations are important to us and to students who may come after you. Please complete them thoughtfully.

Detailed Course Schedule

The course schedule below is tentative and subject to minor changes.

First Half

Session 1: Artificial Intelligence and Machine Learning in a Nutshell (May/08/2024)

Course

- Introduction to Each Other
- Course Introduction
- Introduction to Artificial Intelligence, Machine Learning, and Deep Learning

Recommended Reading

- *The Elements of Statistical Learning* (2nd Edition), 2009, by Trevor Hastie, Robert Tibshirani, Jerome Friedman, https://hastie.su.domains/ElemStatLearn/.
- *Probabilistic Machine Learning: An Introduction*, 2022, by Kevin Murphy, https://probml.github.io/pml-book/book1.html.
- Mullainathan, Sendhil, and Jann Spiess. 2017. Machine learning: an applied econometric approach. *Journal of Economic Perspectives* 31(2): 87-106.
- Athey, Susan, and Guido W. Imbens. 2019. *Machine learning methods that economists should know about. Annual Review of Economics* 11: 685-725.
- Hofman, Jake M., et al. 2021. Integrating explanation and prediction in computational social science. *Nature* 595.7866: 181-188.
- Bastani, Hamsa, Dennis Zhang, and Heng Zhang. 2022. Applied machine learning in operations management. *Innovative Technology at the Interface of Finance and Operations*. Springer: 189-222.
- Kelly, Brian, and Dacheng Xiu. 2023. Financial machine learning, *SSRN*, https://ssrn.com/abstract=4501707.
- *Deep Learning*, 2016, by Ian Goodfellow, Yoshua Bengio and Aaron Courville, https://www.deeplearningbook.org/.
- *Dive into Deep Learning* (2nd Edition), 2023, by Aston Zhang, Zack Lipton, Mu Li, and Alex J. Smola, https://d2l.ai/.
- *Probabilistic Machine Learning: Advanced Topics*, 2023, by Kevin Murphy, https://probml.github.io/pml-book/book2.html.
- *Deep Learning with PyTorch*, 2020, by Eli Stevens, Luca Antiga, and Thomas Viehmann.

Homework

- Problem Set 1: Python Basics; Bias-Variance Trade-off; Cross Validation.

Session 2: Prediction in Business and Traditional Natural Language Processing (May/10/2024)

Course

- Prediction Problems in Business Research
- Pre-processiong and Word Representation in Natural Language Processing
- N-Gram and Naïve Bayes

Recommended Reading

- Kleinberg, Jon, Jens Ludwig, Sendhil Mullainathan, and Ziad Obermeyer. 2015. Prediction policy problems. *American Economic Review* **105**(5): 491-495.
- Gu, Shihao, Brian Kelly, and Dacheng Xiu. 2020. Empirical asset pricing with machine learning. *Review of Financial Studies* 33: 2223-2273.
- Kleinberg, Jon, Himabindu Lakkaraju, Jure Leskovec, Jens Ludwig, and Sendhil Mullainathan. 2018. Human decisions and machine predictions. *Quarterly Journal of Economics* **133**(1): 237-293.
- Bajari, Patrick, Denis Nekipelov, Stephen P. Ryan, and Miaoyu Yang. 2015. Machine learning methods for demand estimation. *American Economic Review*, **105**(5): 481-485.
- Farias, Vivek F., and Andrew A. Li. 2019. Learning preferences with side information. *Management Science* **65**(7): 3131-3149.
- Gentzkow, Matthew, Bryan Kelly, and Matt Taddy. 2019. Text as data. *Journal of Economic Literature*, **57**(3): 535-574.
- Gentzkow, Matthew, Shapiro, Jesse M., and Taddy, Matt. 2019. Measuring group differences in high-dimensional choices: method and application to congressional speech. *Econometrica*, **87**(4): 1307-1340.
- Hansen, Stephen, Michael McMahon, and Andrea Prat. 2018. Transparency and deliberation within the FOMC: A computational linguistics approach. *Quarterly Journal of Economics*, **133**(2): 801-870.
- Chapters 2, 12 & 13, *Introduction to Information Retrieval*, 2008, Cambridge University Press, by Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, https://nlp.stanford.edu/IR-book/information-retrieval-book.html.

Session 3: Natural Language Processing (II): Deep Learning (May/11/2024)

Course

- Word-to-Vector

- Recurrent Neural Networks, Sequence-to-sequence
- Attention Mechanism, Transformer

Recommended Reading

- Mikolov, Tomas, Ilya Sutskever, Kai Chen, Greg Corrado, and Jeff Dean. 2013. Efficient estimation of word representations in vector space. *ArXiv Preprint* arXiv:1301.3781.
- Mikolov, Tomas, Ilya Sutskever, Kai Chen, Greg Corrado, and Jeff Dean. 2013. Distributed representations of words and phrases and their compositionality. *Advances in Neural Information Processing Systems (NeurIPS)* 26.
- Pennington, Jeffrey, Richard Socher, and Christopher Manning. 2014. Glove: Global vectors for word representation. *Proceedings of the 2014 conference on empirical methods in natural language processing (EMNLP)* (pp. 1532-1543).
- Part V, *Lecture Notes for CS224n: Natural Language Processing with Deep Learning*, by Christopher D. Manning, https://web.stanford.edu/class/cs224n/.
- Sutskever, Ilya, Oriol Vinyals, and Quoc V. Le. 2014. Sequence to sequence learning with neural networks. *Advances in neural information processing systems*, **27**.
- Bahdanau, Dzmitry, KyungHyun Cho, and Yoshua Bengio. 2014. Neural machine translation by jointly learning to align and translate. *ArXiv preprint* arXiv:1409.0473, https://arxiv.org/abs/1409.0473.
- Timoshenko, Artem, and John R. Hauser. 2019. Identifying customer needs from user-generated content. *Marketing Science*, **38**(1): 1-20.
- Sarzynska-Wawer, Justyna, Aleksander Wawer, Aleksandra Pawlak, Julia Szymanowska, Izabela Stefaniak, Michal Jarkiewicz, and Lukasz Okruszek. 2021. Detecting formal thought disorder by deep contextualized word representations. *Psychiatry Research*, **304**, 114135.
- Li, Kai, Feng Mai, Rui Shen, Xinyan Yan. 2021. Measuring corporate culture using machine learning. *Review of Financial Studies*, **34**(7): 3265-3315.
- Parts 1, 2, 5, 6, and 8 *Lecture Notes for CS224n: Natural Language Processing with Deep Learning*, by Christopher D. Manning, https://web.stanford.edu/class/cs224n/.

Homework

- Problem Set 2: Word2Vec and LSTM for Sentiment Analysis.

Session 4: Natural Language Processing (III): Large Language Models (May/12/2024)

Course

- Homework Recap
- Transformer, BERT, GPT

- Pre-training, Fine-tuning
- Prompting, Instruction Fine-tuning, Reinforcement Learning with Human Feedback, In-Context Learning, Chain-of-Thought, Emergent Abilities, LLM Training, and Beyond
- LLM and Generative AI in Business Research

Recommended Reading

- Part 10, *Lecture Notes for CS224n: Natural Language Processing with Deep Learning*, by Christopher D. Manning, https://web.stanford.edu/class/cs224n/.
- Chapter 11, Chapter 15.8, *Dive into Deep Learning* (2nd Edition), 2023, by Aston Zhang, Zack Lipton, Mu Li, and Alex J. Smola, https://d2l.ai/.
- Vaswani, Ashish, et al. 2017. Attention is all you need. *Advances in Neural Information Processing Systems*, **30**.
- Devlin, Jacob, Ming-Wei Chang, Kenton Lee, Kristina Toutanova. 2018. BERT: Pre-training of deep bidirectional transformers for language understanding. *ArXiv preprint* arXiv:1810.04805, https://arxiv.org/abs/1810.04805.
- Radford, Alec, Karthik Narasimhan, Tim Salimans, and Ilya Sutskever. 2018. Improving language understanding by generative pre-training, https://cdn.openai.com/research-covers/language-unsupervised/language_understanding_paper.pdf
- Brown, Tom, et al. 2020. Language models are few-shot learners. *Advances in neural information processing systems*, **33**, 1877-1901.
- Huang, Allen H., Hui Wang, and Yi Yang. 2023. FinBERT: A large language model for extracting information from financial text. *Contemporary Accounting Research*, **40**(2): 806-841.
- Wei, Jason, et al. 2021. Finetuned language models are zero-shot learners. *ArXiv preprint* arXiv:2109.01652, https://arxiv.org/abs/2109.01652.
- Wei, Jason, et al. 2022. Emergent abilities of large language models. *ArXiv preprint* arXiv:2206.07682, https://arxiv.org/abs/2206.07682.
- Ouyang, Long, et al. 2022. Training language models to follow instructions with human feedback. *Advances in Neural Information Processing Systems*, **35**, 27730-27744.
- Wei, Jason, et al. 2022. Chain-of-thought prompting elicits reasoning in large language models. *Advances in Neural Information Processing Systems*, **35**, 24824-24837.
- Kaplan, Jared. 2020. Scaling laws for neural language models. *ArXiv preprint* arXiv:2001.08361, https://arxiv.org/abs/2001.08361.
- Hoffmann, Jordan, et al. 2022. Training compute-optimal large language models. *ArXiv preprint* arXiv:2203.15556, https://arxiv.org/abs/2203.15556.

- Shinn, Noah, et al. 2023. Reflexion: Language agents with verbal reinforcement learning. *ArXiv preprint* arXiv:2303.11366, https://arxiv.org/abs/2303.11366.
- Reisenbichler, Martin, Thomas Reutterer, David A. Schweidel, and Daniel Dan. 2022. Frontiers: Supporting content marketing with natural language generation. *Marketing Science*, **41**(3): 441-452.
- Noy, Shakked and Whitney Zhang. 2023. Experimental evidence on the productivity effects of generative artificial intelligence. *Science*, **381**: 187-192.
- Romera-Paredes, B., Barekatain, M., Novikov, A. et al. 2023. Mathematical discoveries from program search with large language models. *Nature*, https://doi.org/10.1038/s41586-023-06924-6.
- Boiko, D.A., MacKnight, R., Kline, B. et al. 2023. Autonomous chemical research with large language models. *Nature*, **624**: 570–578. https://doi.org/10.1038/

Second Half

Session 5: Image Processing and Computer Vision (I) (May/15/2024)

Course

- Image Classification, Traditional Classifiers
- Convolutional Neural Networks (LeNet, AlexNet, ResNet, and Beyond)
- Vision Transformers

Recommended Reading

- *Course Notes for CS231n: Deep Learning for Computer Vision*, by Fei-Fei Li, https://cs231n.github.io/.
- Chapters 7 and 8, *Dive into Deep Learning* (2nd Edition), 2023, by Aston Zhang, Zack Lipton, Mu Li, and Alex J. Smola, https://d2l.ai/.
- Krizhevsky, Alex, Ilya Sutskever, and Geoffrey E. Hinton. 2012. Imagenet classification with deep convolutional neural networks. *Advances in Neural Information Processing Systems*, **25**.
- He, Kaiming, Xiangyu Zhang, Shaoqing Ren and Jian Sun. 2016). Deep residual learning for image recognition. *Proceedings of the IEEE conference on computer vision and pattern recognition*, 770-778.
- Dosovitskiy, Alexey, et al. 2020. An image is worth 16x16 words: Transformers for image recognition at scale. ArXiv preprint, *arXiv:2010.11929*.
- Jean, Neal, Marshall Burke, Michael Xie, Matthew W. Davis, David B. Lobell, and Stefand Ermon. 2016. Combining satellite imagery and machine learning to predict poverty. *Science*, **353**(6301), 790-794.

- Zhang, Mengxia and Lan Luo. 2023. Can consumer-posted photos serve as a leading indicator of restaurant survival? Evidence from Yelp. *Management Science* **69**(1): 25-50.

Homework

- Problem Set 3: Implementing AlexNet and ResNet.

Session 6: Computer Vision (II) (May/16/2024)

Course

- Data Augmentation,
- Objective Detection and Image Segmentation
- Video Understanding

Recommended Reading

- *Course Notes for CS231n: Deep Learning for Computer Vision*, by Fei-Fei Li, https://cs231n.github.io/.
- Chapter 14, *Dive into Deep Learning* (2nd Edition), 2023, by Aston Zhang, Zack Lipton, Mu Li, and Alex J. Smola, https://d2l.ai/.
- Dosovitskiy, Alexey, et al. 2020. An image is worth 16x16 words: Transformers for image recognition at scale. *ArXiv preprint* arXiv:2010.11929: https://arxiv.org/abs/2010.11929.
- Redmon, Joseph, Santosh Divvala, Ross Girshick, and Ali Farhadi. 2016. You only look once: Unified, real-time object detection. *Proceedings of the IEEE conference on computer vision and pattern recognition* (pp. 779-788).
- Karpathy, A., Toderici, G., Shetty, S., Leung, T., Sukthankar, R. and Fei-Fei, L., 2014. Large-scale video classification with convolutional neural networks. Proceedings of the IEEE conference on Computer Vision and Pattern Recognition (pp. 1725-1732).
- Liu, Liu, Dzyabura, Daria, Mizik, Natalie. 2020. Visual listening in: Extracting brand image portrayed on social media. *Marketing Science* **39**(4): 669-686.
- Glaeser, Edward L., Scott D. Kominers, Michael Luca, and Nikhil Naik. 2018. Big data and big cities: The promises and limitations of improved measures of urban life. *Economic Inquiry*, **56**(1): 114-137.
- Zhang, S., Xu, K. and Srinivasan, K., 2023. Frontiers: Unmasking Social Compliance Behavior During the Pandemic. Marketing Science, 42(3), pp.440-450.
- Yang, Jeremy, Juanjuan Zhang, and Yuhan Zhang. 2023. Engagement that sells: Influencer video advertising on TikTok. *Available at SSRN*: https://ssrn.com/abstract=3815124.

Session 7: Unsupervised Learning (I): Clustering, Topic Modeling & VAE (May/17/2024)

Course

- Clustering, EM Algorithm
- Dirichlet Latent Allocation, Topic Modeling
- Variational Auto-Encoder

Recommended Reading

- Chapters 8.5 and 14, *The Elements of Statistical Learning* (2nd Edition), 2009, by Trevor Hastie, Robert Tibshirani, Jerome Friedman, https://hastie.su.domains/ElemStatLearn/.
- Blei, David M., Ng, Andrew Y., and Jordan, Michael I. 2003. Latent dirichlet allocation. *Journal of Machine Learning Research*, **3**(Jan): 993-1022.
- Ghose, Anindya, Panagiotis G. Ipeirotis, and Beibei Li. 2018. Modeling consumer footprints on search engines: An interplay with social media. *Management Science* **65**(3): 1363-1385.
- Netzer, Oded, Alain Lemaire, and Michal Herzenstein. 2019. When words sweat: Identifying signals for loan default in the text of loan applications. *Journal of Marketing Research*, **56**(6): 960-980.
- Liu, Jia and Olivier Toubia. 2018. A semantic approach for estimating consumer content preferences from online search queries. *Marketing Science* **37**(6): 930-952.
- Mejia, Jorge, Shawn Mankad, and Anandasivam Gopal. 2021. Service quality using text mining: Measurement and consequences. *Manufacturing & Service Operations Management* **23**(6): 1354-1372.
- Mueller, Hannes, and Christopher Rauh. 2018. Reading between the lines: Prediction of political violence using newspaper text. *American Political Science Review*, **112**(2): 358-375.
- Kingma, D.P. and Welling, M., 2013. Auto-encoding Variational Bayes. arXiv preprint *arXiv:1312.6114*.
- Kingma, D.P. and Welling, M., 2019. An introduction to variational autoencoders. *Foundations and Trends® in Machine Learning*, 12(4), pp.307-392.
- Tian, Z., Dew, R. and Iyengar, R., 2023. Mega or Micro? Influencer Selection Using Follower Elasticity. *Journal of Marketing Research*.

Homework

- Problem Set 4: EM Algorithm; Topic Modeling.

Session 11: Unsupervised Learning (II): Diffusion Models (May/18/2024)

Course

- Denoised Diffusion Probabilistic Models
- Latent Diffusion Models, CLIP, Imagen

- Diffusion Transformers

Recommended Reading

- *Course Notes for CS231n: Deep Learning for Computer Vision*, by Fei-Fei Li, https://cs231n.github.io/.
- *Denoising Diffusion-based Generative Modeling*, CVPR2022 Tutorial, https://cvpr2022-tutorial-diffusion-models.github.io/.
- Ho, Jonathan, Ajay Jain, and Pieter Abbeel. 2020. Denoising diffusion probabilistic models. *Advances in Neural Information Processing Systems* **33**: 6840-6851.
- Song, Yang et al. 2020. Score-based generative modeling through stochastic differential equations. *ArXiv preprint* arXiv:2011.13456, https://arxiv.org/abs/2011.13456.
- Chan, S.H., 2024. Tutorial on Diffusion Models for Imaging and Vision. *arXiv preprint* arXiv:2403.18103.
- Peebles, W. and Xie, S., 2023. Scalable diffusion models with transformers. *Proceedings of the IEEE/CVF International Conference on Computer Vision*, 4195-4205.
- Ludwig, J. and Mullainathan, S., 2024. Machine learning as a tool for hypothesis generation. *Quarterly Journal of Economics*, 139(2), 751-827.
- Burnap, A., Hauser, J.R. and Timoshenko, A., 2023. Product aesthetic design: A machine learning augmentation. *Marketing Science*, 42(6), 1029-1056.
- Course Notes (Lecture 6) for CS294-158-SP24: Deep Unsupervised Learning, taught by Pieter Abbeel, Wilson Yan, Kevin Frans, Philipp Wu.
- CVPR 2022 Tutorial: Denoising Diffusion-based Generative Modeling: Foundations and Applications, by Karsten Kreis, Ruiqi Gao, and Arash Vahdat.