機器學習 (Machine Learning)
Teacher: Jerry Hsu, 中原大學, 電機資訊學院, 工業與系統工程學系
Email：chhsu135 AT gmail
Email subject: Machine learning, your name (郵件主旨：機器學習，姓名)

- Class material
    - Python and the data files, homework problems.
    - Please look at gurobi_installation.pdf under the directory Gurobi for further information. The optimization solver will be used in HW 5 and 6. The learning curve is higher if you do not have any background course in optimization, so it is better to start earlier.
- Google Colab
- The background knowledge for this course (and data science) is as follows. The following courses cover more than what we need. Please study these free courses first so that you can get the most from this course.
    - https://www.coursera.org/specializations/mathematics-for-machine-learning-and-data-science#courses
    - https://cs50.harvard.edu/python/2022/
- 2/26: Please upload your files to i-learning.cycu.edu.tw under the directory HW for each group or individual.
    - Individual：SigninNo-HW**.pdf, e.g, 02-HW01.pdf, 02-HW01.ipynb, 02-HW01.html. Please add a zero so that it will show up in sequence when we download the files from ilearning.
    - Group：Group-GroupNo-HW**.pdf, e.g., Group-17-HW01.pdf, Group-17-HW01.html, Group-17-HW01.ipynb。Please write down the information of your group members on the first line of your Word file in case some member does not participate in this homework.
    - If there are many files, please add extension, e.g., 02-HW01-**.html, Group-17-HW01-**.html
    - Please transform your ipynb file into HTML file under “File/Download as/HTML (.html)”.
    - If you submit your homework assignment, some students will be chosen randomly to present their results.

- Please use Word to write down your results and observations in English and transform the file into a pdf file. For each question in your Word file, please provide a short/key Python program and highlight/explain your results.
- If you submit your homework assignment, some students will be chosen randomly to present your results.
- Final project proposal: Information of your team members, data source or paper information, problem to be solved and possible approaches, the individual task for each member, conjectured outcome of your final project. If your group member = 2, please talk to me earlier in case your project scope is too small to accommodate many people.

- 2/28: 採翻轉教室教學 (teaching by flipped classroom)
  - Please listen to the videos, think about the review questions simultaneously, and write down your responses on the provided Google form before the class.
    - For international students: machine learning, optimization and ML
    - For local students: machine learning, optimization and ML
  - In the class:
    - We will discuss the review questions first.
    - I will then answer questions at slido.
    - Please ask questions about the course content, Python programs, work on the homework assignment, and discuss the final project.

- 授課目標:
  - Machine learning is to design appropriate algorithms to improve its predictive capability through data updating and environmental interaction. This course emphasizes supervised learning.
  - By using interesting examples, we will build different mathematical models and use Python to synthesize the problem.
  - After taking the course, the students will learn the whole application cycle and possess the foundation of a data scientist to solve the problems of an enterprise or organization.
  - Besides the traditional machine learning models, we will also use mixed integer programming and robust optimization to learn new results in this field and solve the formulation by Gurobi.

    - We will use flipped classrooms. Through interactive discussion and learning-by-doing, this course will enhance the capability of students to solve real-world problems.
- 先修知識:同學有修過任何的程式設計課，有控制結構 (if/for) 和使用物件的觀念。我會解說相關的數學和程式碼，基礎的觀念終身受用。如果不確定，歡迎詢問我。
    - We will provide some Python scripts in lecture 2.
    - For a more comprehensive review, you could study my course material. 如果同學們對 Python 不熟悉，建議先看一下老師影片的前 4 講 (或者 YouTube 搜尋 "許志華 Python 程式設計")。前 4 講包含了控制結構 (control structure) 和資料分析的三大套件 (Pandas, NumPy, Matplotlib)。3-3-2 Identification number (身分證字號) 是程式邏輯很好的作業。第五講則是說明 NumPy 的妙用，和演算法概念。如果需要做資料前處理，需要第六講和第七講;課程網頁中，Python 檔案中的作業 6-2，讓您了解 Python 強大的功能。
    - Python: learnpython.org, python.org, Python Data Science Handbook, 第一次用就上手, 作圖顯示中文
    - 寫程式除錯的方法
        - 在 jupyter 下，(例如在 for loop 中) 印出 (print) 變數的名稱，觀察其值是否是你想要的。
        - 或者將 ipynb 轉成 Python 檔 (.py)，在該檔的 File 處選 Download as / Python (.py)。然後使用anaconda 下的 Spyder 打開該 Python 檔，逐行執行時，觀察 Spyder 右上方變數的值。
- 教科書:
    - Aurélien Géron, *Hands-on Machine Learning with Scikit-Learn, Keras and TensorFlow*, O'Reilly, 3rd edition, 2022. (Python, nice mathematical introduction) (second edition, 2019. 已置於指定參考書架上。可使用館藏目錄之教師指定參考書查詢功能，依「課程名稱」或「教師姓名」進行資料檢索) GitHub (1st, 2nd)
    - Dimitris Bertsimas and Jack Dunn, *Machine Learning Under a Modern Optimization Lens*, Dynamic Ideas LLC, 2019. (MIT course)
- 參考資料:
    - 李宏毅, machine learning, 2021 spring (English version)
    - 林軒田, 機器學習基礎, 機器學習技術, Coursera
    - 蔡炎龍, 深度學習, YouTube (with slides)
    - Sebastian Raschka, Python 機器學習, 博碩文化, 2016
    - UC Berkeley, *Data 8: Foundations of Data Science*. (Nice introduction to the field of statistics, computational thinking, and tools.)
    - Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
    - Christos Christofidis, Awesome Deep Learning (new)

    - Carlos Fernandez-Granda, *Mathematical Tools for Data Science*, NYU.
    - Ian Goodfellow, Yoshua Bengio, and Aaron Courville, *Deep Learning*, The MIT Press, 2016.
    - Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer, second edition, 2011.
    - David J. Malan, CS50's Introduction to Artificial Intelligence with Python, Harvard University.
    - Wes McKinney, *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython*, O'Reilly Media, 2013.
    - MITx: The Analytics Edge (Nice review of optimization in machine learning), or MIT OCW
    - Andrew Ng, *Machine Learning*, Coursera. (Very famous and popular)
    - David S. Rosenberg, *Foundations of Machine Learning*, Bloomberg
    - Manohar Swamynathan, *Mastering Machine Learning with Python in Six Steps*, Apress, 2017.
    - Steve Tally, Amazon's Machine Learning University expands with MLU Explains: Fun visual essays explain key concepts of machine learning, Amazon, July 12, 2022. (Visual explanations)
- 領域知識和其他
    - 我的 blog：機器學習，資料探勘，my data mining course in R
    - 李傑，工業大數據：工業 4.0 時代的智慧轉型與價值創新，天下雜誌，2016
    - 李開復、王詠剛，人工智慧來了，天下文化，2017
    - Pedro Domingos，張正苓、胡玉城譯，大演算：機器學習的終極演算法將如何改變我們的未來，創造新紀元的文明？，三采，2016
    - Jay Lee, *Industrial AI: Applications with Sustainable Performance*, Shanghai Jiao Tong University Press, 2020.
    - Foster Provost and Tom Fawcett, *Data Science for Business*, Oreilly & Associates Inc, 2013. 陳亦苓譯，資料科學的商業運用，歐萊禮，碁峰代理，2016，ISBN 9789864760268
- 評分方式：授課老師保留調整分數之權利
    - (individual)(On-time) attendance and class participation 10% (2 leaders for the exercises)
    - (individual) Answering and presenting review questions 15%
    - Homework assignment and presentation 30%. (You are encouraged to discuss with your classmates, but please submit your individual/group solution.)
    - (individual) Midterm Python programming 15%
    - Final project and presentation 30% (Tips)

Some additional information for the midterm paper presentation and the final project as a group:

- The midterm paper presentation: Read a paper and present it by using PowerPoint. If you want to choose another paper in the list, please discuss with me first.
- The final project:
    - Implement several algorithms by using 1 dataset and compare their performance indexes
    - Experiment (and extend) the algorithms in a paper coming with codes
- Python code:
    - MoBagel 行動貝果 Interview cases
    - Kaggle
- arxiv.org: search author "Bertsimas" (highly recommend)
    - If you are interested, please let me know and we will discuss it.
        - The authors provide some working codes. Your job is to understand the codes and modify them.
        - I have written many codes for many of the papers. There exist some bugs and issues to be handled.
- Google scholar: Search Bertsimas (optimization and machine learning), Chen-Fu Chien (many articles in machine learning)
- *Journal of Machine Learning Research*: Many papers come with code.
- Please search "vpn cycu" and use your school account to download the files at any place. If not, please use the computers in the school lab or the library to download it.
- Classic papers (at the end "Interesting readings" of this webpage)

- R. Anderson, J. Huchette, W. Ma, C. Tjandraatmadja, and J.P. Vielma, Strong mixed-integer programming formulations for trained neural networks. *Mathematical Programming,* 2020*,* 183(1-2):3-39, ISSN 14364646, URL http://dx.doi.org/10.1007/s10107-020-01474-5.
- Maxime Amram, Jack Dunn, Jeremy J.Toledano, and Ying Daisy Zhuo, Interpretable predictive maintenance for hard drives, *Machine Learning with Applications*, Volume 5, 15 September 2021, 100042.
- Yoshua Bengio, Andrea Lodi, and Antoine Prouvost, Machine Learning for Combinatorial Optimization: a Methodological Tour d'Horizon, *European Journal of Operational Research*, 2021. (Survey article. Please find papers inside it to present.)
- Julius Berner, Philipp Grohs, Gitta Kutyniok, and Philipp Petersen, The modern mathematics of deep learning, arXiv preprint arXiv:2105.04026, 2021. (Survey article. Please find papers inside it to present.)
- Max Biggs, Wei Sun, and Markus Ettl, Model Distillation for Revenue Optimization: Interpretable Personalized Pricing, *Proceedings of the 38th International Conference on Machine Learning (ICML)*, PMLR 139, 2021.
- Sébastien Bubeck and Mark Sellke, A Universal Law of Robustness via Isoperimetry, arXiv:2105.12806v3
- Kuo, C.-J., Chien, Chen-Fu, and Chen, C.-D. (2011), "Manufacturing Intelligence to Exploit the Value of Production and Tool Data to Reduce Cycle Time," *IEEE Transactions on Automation Science and Engineering*, 8(1), 103-111. (2011 IEEE TASE Best Paper Award)
- Shu-Kai S. Fan, Chia-Yu Hsu, Du-Ming Tsai, Fei He, and Chun-Chung Cheng, Data-Driven Approach for Fault Detection and Identification in Semiconductor

Manufacturing, *IEEE Transactions on Automation Science and Engineering*, Volume: 17, Issue: 4, Oct. 2020, Page(s): 1925 - 1936.

- Jacob Feldman, Dennis J. Zhang, Xiaofei Liu, and Nannan Zhang (2021) Customer Choice Models vs. Machine Learning: Finding Optimal Product Displays on Alibaba. *Operations Research* 70(1):309-328. (Best OM Paper in Operations Research Award: Finalist, pdf, implementation details)
- K.J. Ferreira, B. H. A. Lee, and D. Simchi-Levi, Analytics for an Online Retailer: Demand Forecasting and Price Optimization. *Manufacturing and Service Operations Management*. Vol. 18, No. 1, Winter 2016, pp. 69-88.
- Y Juan, Y Zhuang, WS Chin, CJ Lin, Field-aware factorization machines for CTR prediction, Proceedings of the 10th ACM conference on recommender systems, 43-50, 2016. (With code)
- Yao Li, Minhao Cheng, Cho-Jui Hsieh, Thomas C. M. Lee., A Review of Adversarial Attack and Defense for Classification Methods. In The American Statistician, 2021.
- Yair Meidan, Boaz Lerner, Gad Rabinowitz, and Michael Hassoun, Cycle-Time Key Factor Identification and Prediction in Semiconductor Manufacturing Using Machine Learning and Data Mining, *IEEE Transactions on Semiconductor Manufacturing*, Volume: 24, Issue: 2, May 2011, Page(s): 237 - 248.
- Xin Pan, Jie Song, and Fan Zhang, Dynamic recommendation of physician assortment with patient preference learning, *IEEE Transactions on Automation Science and Engineering*, vol. 16, no. 1, pp. 115-126, 2019. (Best Paper Award)
- Huashuai Qu, Ilya O. Ryzhov, Michael C. Fu, Eric Bergerson Megan, and Kurka Ludek Kopacek, Learning Demand Curves in B2B Pricing: A New Framework and

Case Study, *Production and Operations Management*, Volume 29, Issue 5, May 2020, Pages: 1287-1306.

- Ravuri, S., Lenc, K., Willson, M. et al., Skilful precipitation nowcasting using deep generative models of radar. *Nature* 597, 672–677 (2021). https://doi.org/10.1038/s41586-021-03854-z
- David Rolnic et al., Tackling Climate Change with Machine Learning, *ACM Computing Surveys*, Volume 55, Issue 2, March 2023, Article No.: 42, pp 1–96, https://doi.org/10.1145/3485128 (Survey article. Please find papers inside it to present.)
- U. Shaham, Y. Yamada, S. Negahban, Understanding adversarial training: Increasing local stability of supervised models through robust optimization, *Neurocomputing*, Volume 307, 13 September 2018, Pages 195-204.
- Duncan Simester, Artem Timoshenko, and Spyros I. Zoumpoulis, Targeting Prospective Customers: Robustness of Machine-Learning Methods to Typical Data Challenges, *Management Science*, 2020, Vol. 66, No. 6, Pages: 2495–2522.
- Berk Ustun and Cynthia Rudin, Learning Optimized Risk Scores. *Journal of Machine Learning Research*, 2019. Shorter version at KDD 2017. (bib for JMLR version) | (bib for KDD version) | (code) (Prof. Rudin provides many codes for their papers.)
- Paul Vicol, Luke Metz, and Jascha Sohl-Dickstein, Unbiased Gradient Estimation in Unrolled Computation Graphs with Persistent Evolution Strategies, *ICML* 2021. (Outstanding Paper Awards).