CMU, Machine Learning Department

10-880 Game-theoretic probability, statistics and learning

Spring 2024: Tue/Thu 3:30 pm – 4:50 pm in DH 1211

CMU Instructor Aaditya Ramdas, aramdas@cmu.edu, http://stat.cmu.edu/~aramdas/
TAs Ben Chugg, benchugg@cmu.edu, https://benchugg.com
Ian Waudby-Smith, ianws@cmu.edu, https://ianws.com/

Office hours

- Aaditya Ramdas: By appointment
- Ben Chugg: Tuesdays 2-3pm, GHC 8014
- Ian Waudby-Smith: Wednesdays 2:30-3:30pm, GHC 8014

Course description We will study the game-theoretic foundation for probability, statistics and learning, and its applications to prediction, testing, estimation and change detection. It will distinctively employ modern concepts around betting, e-values, and martingales, effectively bridging Bayesian, frequentist and model-free or adversarial perspectives on these topics.

Prerequisites PhD level training in probability, statistics and machine learning. You should preferably already have completed some graduate courses in these areas. Exceptions can be made for students with strong mathematical backgrounds.

Note the important dates on the **CMU academic calendar**.

Basis of grading (12 units)
(A) Homeworks 60% (3 HWs, due Feb, Mar, Apr)
(B) Class participation 10% (attendance, scribing)
(C) Course project 30% (report due May)

Auditing is permitted but only with a signed audit form. Auditing students can drop (A), but (B) and (C) are heavily encouraged.

Accommodations for Students with Disabilities If you have a disability letter from the Disability Resources office, discuss your accommodations and needs with us as soon as possible. We will work with you to ensure that accommodations are provided as appropriate. If you suspect you may have a disability and would benefit from accommodations, but are not yet registered with the Office of Disability Resources, you may contact them at access@andrew.cmu.edu.

Plagiarism & Academic Integrity
Your work must be your own. Any student plagiarizing or violating academic integrity policies will **automatically fail the course** and will be brought to the university disciplinary board. By

registering for this course, you agree to this policy. If you are unsure about what constitutes plagiarism, consult us BEFORE you submit your work. You may review those standards, including what plagiarism is, here:
http://www.cmu.edu/policies/documents/AcademicIntegrity.htm
http://www.cmu.edu/academic-integrity/index.html

Key resources for students

[SV1] Game-Theoretic Foundations for Probability and Finance.
G. Shafer and V. Vovk,
Wiley 2019

[SV2] Probability and Finance: It's Only a Game
G. Shafer and V. Vovk,
Wiley 2001

[S] Testing by betting: A strategy for statistical and scientific communication.
G. Shafer.
Journal of the Royal Stat. Society, Series A., with discussion, 2021 proc

[WSR] Estimating means of bounded random variables by betting.
I. Waudby-Smith, A. Ramdas.
Journal of the Royal Stat. Society, Series B, 2023, with discussion arxiv

[GHK] Safe Testing
P. Grünwald, R. de Heide, W. Koolen.
Journal of the Royal Stat. Society, Series B, 2024, with discussion arxiv

[RRLK] Admissible anytime-valid sequential inference must rely on nonnegative martingales.
A. Ramdas, J. Ruf, M. Larsson, W. Koolen
ArXiv, 2020 arxiv

[WRS] Universal inference.
L. Wasserman, A. Ramdas, S. Balakrishnan.
PNAS, 2020, arxiv proc

[VW1] E-values: Calibration, combination, and applications.
V. Vovk, R. Wang.
Annals of Statistics, 2021, arxiv

[WR1] False discovery rate control with e-values.
R. Wang, A. Ramdas.
Journal of the Royal Stat. Society, Series B, 2022 arxiv

[RRLK] Testing exchangeability: fork-convexity, supermartingales, and e-processes
A. Ramdas, J. Ruf, M. Larsson, W. Koolen
Intl. Journal of Approximate Reasoning, 2022 arxiv

[WSR2] Confidence sequences for sampling without replacement.
I. Waudby-Smith, A. Ramdas.
Neural Information Processing Systems, 2020. arxiv

[HRMS1] Time-uniform Chernoff bounds via nonnegative supermartingales.
S. Howard, A. Ramdas, J. Sekhon, J. McAuliffe
Probability Surveys, 2020 arxiv proc

[HRMS2] Time-uniform, nonparametric, nonasymptotic confidence sequences.
S. Howard, A. Ramdas, J. Sekhon, J. McAuliffe
Annals of Statistics, 2021 arxiv