ICS 636 Information Theory in Machine Learning

15 week syllabus, two lectures per week. Lecture numbers indicated in bold font on the left.

1 Introductory Lecture: Introduction to information theory in machine learning.

2-6 Foundations refresher:

- Linear algebra.
- Calculus of variations.
- Probability theory.
- Bayesian inference.

7-8 A motivating example: Cluster analysis.

- Concepts and issues.
- Simple example: K-means algorithm.
- Selected applications to contemporary problems. Subject areas are listed below - specifics are adjusted to student interests.
- Limitations of the algorithm, computational and conceptual issues.
- Mixture models.
- Spectral methods.

9-12 Introduction to Information theory:

- Entropy and Information.
- Channel capacity.
- Coding theorems.
- Rate-distortion theory.

13-18 Re-visiting Cluster Analysis from an information theoretic point of view:

- Soft K-means.
- Deterministic Annealing.
- Information Bottleneck algorithm.
- Choosing the number of clusters.
- Selected applications to contemporary problems. Subject areas are listed below - specifics are adjusted to student interests.

19 The Info-max idea and Independent Component Analysis (ICA).

20-24 Modeling dynamical systems:

- Time series analysis refresher.
- Computational mechanics: causal states and the ϵ-Machine.
- Optimal Causal Inference.
- Adaptive causal filters.
- Selected applications to contemporary problems. Subject areas are listed below - specifics are adjusted to student interests.

25-30 Behavioral learning:

- Reinforcement learning refresher.
- Active learning and optimal experiment design.
- Interactive learning.
- Information theoretic approach to exploration and curiosity in reinforcement learning.
- Selected applications to robotics and animal behavior.

Application subject areas include: robotics, computer vision, speech recognition, time series analysis, renewable energies, mathematical finance, geology, astronomy, learning formal grammars, medical imaging, and bioinformatics. Students are strongly encouraged to add subjects.