Graduate Course on “Algorithmic Information Theory, Complexity, and Data Compression”

1. Basics: Information and Computation
    - Information and codes
    - Random variables and dynamical systems
    - Computability
    - Turing machines
    - Finite automata
2. Entropy
    - Origins of entropy in physics: thermodynamics
    - Shannon’s information theoretic entropy
    - Entropy in dynamical systems
    - Algorithmic entropy: Kolmogorov complexity
3. Complexity
    - Algorithmic randomness: finite strings
    - Algorithmic randomness: infinite strings
    - Randomness vs entropy
    - Typicality: generic points in dynamical systems
    - Randomness vs typicality
    - Normality and finite automata
4. Coding and Data Compression
    - Universal codes
    - Compression and entropy
    - Lossless data compression: Lempel-Ziv compression
    - Lossy compression: rate distortion theory
    - Compressors as approximations to Kolmogorov complexity
5. Applications
    - Fractal dimension, entropy, and Kolmogorov complexity
    - Inductive inference via Kolmogorov complexity, Minimum Description Length principle
    - Clustering by data compression

Bibliography

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- T. M. Cover and J. A. Thomas. Elements of information theory. Wiley-Interscience, 2006.
- R. G. Downey and D. R. Hirschfeldt. Algorithmic randomness and complexity. Springer, 2010.
- M. Li and P. Vitányi. An introduction to Kolmogorov complexity and its applications. Springer, 1997.
- P. C. Shields. The ergodic theory of discrete sample paths. American Mathematical Society, 1996.