TEL AVIV UNIVERSITY אוניברסיטת תל-אביב

THE IBY AND ALADAR FLEISCHMAN FACULTY OF ENGINEERING

הפקולטה להנדסה
על שם איבי ואלדר פליישמן

Information Theory 2

Prerequisite: Information Theory 1.

Course Objectives: Introduction to network information theory (NIT), the available techniques for treating different network information-theoretic scenarios, and (if time permits) the relation between estimation and information theory. Particular emphasis will be given to Gaussian settings.

Tentative Course Outline: (not all topics will be covered each year)

- **Introduction:** Review of basic NIT settings: multiple-access channel (MAC), broadcast channel (BCC), interference channel, distributed source coding; channels with state: source and channel coding with side information (SI), compound channel, arbitrary varying channel; interactive settings: communication with feedback, information-theoretic security, two-way channel; multi-hop channels: relay channel, diamond/parallel relay channel, butterfly channel, two-way relay channel; difference from point-to-point settings.

- **Gaussian point-to-point channel:** Kac–Bernstein theorem and the Gaussian input as an optimizer.

- **Multiple-access channel:** Capacity region; time-sharing; Gaussian MAC: successive decoding ("onion peeling"), rate-splitting.

- **Distributed lossless source coding:** The Slepian–Wolf (SW) problem; random binning; second user as a helper—coded SI; Wyner & Ahlswede–Körner problem; MAC–SW separation failure.

- **Side-information settings:** Channel coding with SI: causal setting (Shannon problem), non-causal setting (Gel'fand–Pinsker problem), "writing on dirty paper"; source coding with SI (Wyner–Ziv problem); distributed lossy source coding ("lossy Slepian–Wolf" problem); CEO problem; Berger–Tung bound.

- **Linear/lattice codes:** Basic definitions, nested linear/lattice codes, modulo-lattice analog codes; schemes for Gaussian SI scenarios.

- **Broadcast channel:** Common-message broadcast, private-message broadcast; degraded BCC, less noisy BCC, more-capable BCC; superposition coding.
- **Interference channel:** Strong/very-strong interference; Hab–Kobayashi region.
- **Additive networks:** Network coding, double-dirty MAC, Körner–Marton problem, compute-and-forward.
- **Multiple-description coding:** Successive refinement, successively-refinable sources, multiple-descriptions coding.
- **Gaussian MIMO channels:** Orthogonal/unitary matrix decomposition; reduction of Gaussian multiple-input multiple-output (MIMO) scenarios to scalar ones; reduction of Gaussian network settings to scalar common-message broadcast.
- **Physical-layer security:** Physical-layer security notions: weak secrecy, strong secrecy, semantic secrecy; wiretap channel, confidential BCC; Gaussian settings.
- **Large deviations:** Method of types, strong typicality, Sanov's theorem; error exponents via Sanov's theorem.

Main References

[1] *Lecture notes from previous years.*

[2] A. El Gamal and Y.-H. Kim, *Network Information Theory.* Cambridge University Press, 2011.

[3] T. M. Cover and J. A. Thomas, *Elements of Information Theory*, 2nd ed. New York: Wiley, 2006.

[4] I. Csiszar and J. Korner, *Information Theory: Coding Theorems for Discrete Memoryless Systems.* New York: Academic Press, 1981.

[5] R. Zamir, *Lattice Coding for Signals and Networks.* Cambridge: Cambridge University Press, 2014.

[6] J. H. Conway and N. J. A. Sloane, *Sphere Packings, Lattices and Groups.* New York, N.Y.: Springer-Verlag, 1988.