Information Theory and Applications

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30 THIRTY YEARS OF SYSTEMS RESEARCH EXCELLENCE

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History

- Multiuser information and coding theory.
- Reliable communication over uncertain channels.
- Information theoretic security.
- Optical communication theory.
- Communication networks.
- Information theory and statistics.

Future Directions

- Algorithm design for sampling rate distortion.
- Function computation over networks.
- Interactive communication for secrecy and privacy.

Sampling Rate Distortion

Objective

- Estimate underlying field from limited spatial and temporal measurements.
- Reconstruct the entire field within specified distortion.

Applications

- Dynamic thermal management for multicore processor chips.
- In-network function computation over distributed sensor network.
- Image restoration and surface reconstruction problems in computer vision.

Questions

- Optimal sampling process: Location and density.
- Optimal compression and reconstruction techniques.
- Optimal sampling-compression-distortion tradeoffs.

Algorithmic issues

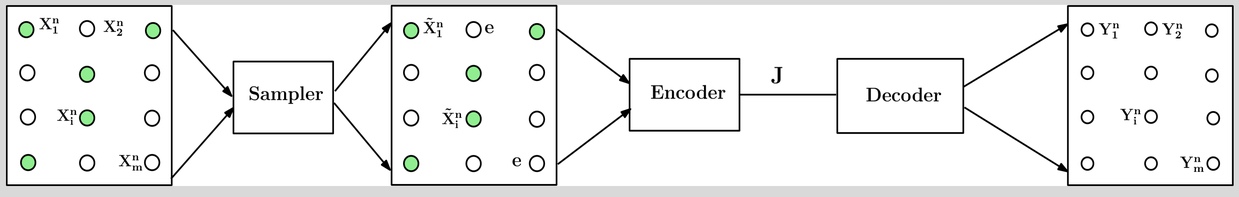
- Optimal sampling of sensing locations under resource constraint.
- Efficient compression of sampled signals for accurate representation of original signals.

Highlights

- Performance of random sampling versus deterministic sampling.
- Structured deterministic sampling can be optimal.
- Separation of compression and estimation.
- Computationally efficient reconstruction: Limited reconstruction + MAP/MMSE estimates can be optimal.

Formulations

- Field is modeled as a set of random variables, $\{X_1, X_2, \ldots, X_m\}$ with a given joint distribution.



- Fixed set sampling:

$$R_A(\Delta) = \min_{\substack{\mathbb{E}[d(X_{\mathcal{M}}, Y_{\mathcal{M}})] \le \Delta \\ X_{\mathcal{M}} \multimap X_A \multimap Y_{\mathcal{M}}}} I(X_A \wedge Y_{\mathcal{M}}), \qquad \Delta_{\min} \le \Delta \le \Delta_{\max}$$

- Memoryless sampling:

$$R_S(\Delta) = \min_{\substack{\mathbb{E}[d(X_{\mathcal{M}}, Y_{\mathcal{M}})] \le \Delta \\ X_{\mathcal{M}} \multimap S X_S \multimap Y_{\mathcal{M}}}} I(X_S \wedge Y_{\mathcal{M}} | S), \qquad \Delta_{\min} \le \Delta \le \Delta_{\max}$$

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