Decision making via End-to-End Lossy Distributed Wireless Cooperative Networks

- A Distributed Hypothesis Testing based Formulation -

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Abstract

The goal of his tutorial is to provide the course takers with the knowledge on Decision-Making Theory by Distributed Hypothesis Testing (DHT) with Lossy Correlated Sources Observations via End-to-End Distributed Lossy Communications. First of all, this tutorial focuses on Mathematical and Information Theoretic background needed to understand the concept, where important Theorems, Lemmas and their practical meanings are explained. Then, this tutorial introduces analytical methods based on the theorems, and the results of numerical calculations for evaluating their performance represented by their corresponding Rate-Distortion function and outage probabilities.

This tutorial applies the theoretical framework of DHT for the decision making via lossy networks. The relationship in the mathematical bases between Wireless Lossy Communications (WLC) and DHT, as well as between WLC and Machine Learning are investigated.

We consider the DHT and WLC Toy Scenario, as:

- Two sources, X and Y are correlated, and the correlation is expressed by random bit flipping $Bern(p_0)$ (if p_0=0.0, X and Y are fully correlated).
- X and Y are lossy-compressed with their rates Rx and Ry, respectively. The DHT Center or Network Destination of WLC aim to decode based on the lossy-compressed data. Let the decoded data be denoted by U. Then, U, Y, X form a Markov chain, U→X→Y in both DHT and WLC. Furthermore, in Machine Learning systems. Also U→X→Y holds where X is the semantic source, U is the semantic decoding result, and Y can be seen as the training sequence.

This tutorial provides the course takers with theoretical sketch in mathematics for those Toy Scenarios where some example cases are used. To help course takers understand the mathematics, a slide set (roughly 100 pages long) will be distributed beforehand. The curse slide set has the following Sections:

1. End-to-End *Lossless* Relaying: Slepian Wolf Theorem with Source-Channel Separation
   a. EXIT Analysis for Source Bit-Flipped MIMO Transmission with Turbo Equalization
   b. Slepian-Wolf Formulation for Lossless Two-Way Relay Networks

2. End-to-End Lossy Distributed Multi-terminal Networks: Rate Distortion Analysis
    a. Wyner-Ziv Formulation for End-to-End Lossy Two-Way Relay Network
    b. Berger-Tung Formulation for Two Source One Helper Network
    c. End-to-End Lossless and Lossy Multiple Access Networks
    d. Two Stage Wyner-Ziv Network: Distortion Transfer Analysis
3. Wyner-Ziv Formulation for Decision Making Process
    a. Revisit of Helper-aided Lossy Networks
    b. Distributed Hypothesis Testing (DHT)
    c. Semantic Communications
    d. Training Process of Machine Learning

The course slides will be available after May 24 at:
https://dspace.jaist.ac.jp/dspace/items-by-authorext?query=id%3D185

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