

# Lehigh University Center for Optical Technologies

## Distributed Source Coding for Sensor Networks

PI: Tiffany Jing Li Graduate Assistants: Ruiyuan Hu, Ramesh Viswanathan  
Department of Electrical and Computer Engineering, Lehigh University

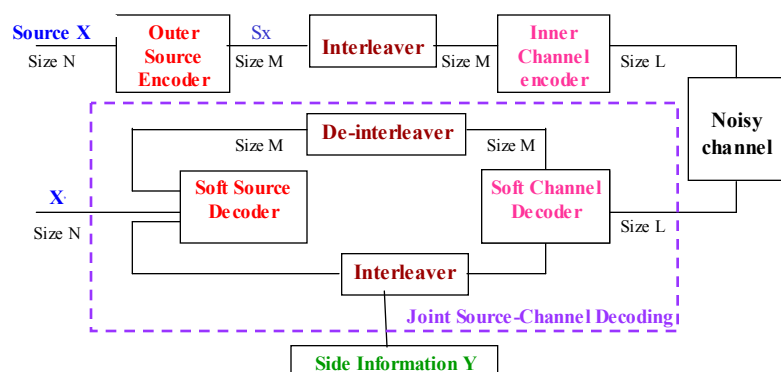
### Motivation of the Work

- Motivation for exploiting distributed source coding (DSC) in sensor networks:
  - Limited transmission power in sensor nodes
  - Lack of communication channels between sensors
- Goal of this work: efficient DSC over noisy channels in sensor networks

#### The Proposed Approach:

- To **separately design** source encoder and channel encoder and **join them using a single (soft iterative) decoder**
  - Shannon's separation theorem
  - The Serially Concatenated Coding (SCC) approach
- Separate and flexible tuning and refining of compression rate and error protection power for efficient distributed source and channel coding

### System Model



#### Assumptions for the system setup:

- Sources X and Y are equiprobable memoryless binary random variables
- Sources X and Y are correlated at the same time instant with  $Pr[X \neq Y] = P < 0.5$ .
- One of the sources, Y, is losslessly available at the joint decoder.

### Coding Procedure

#### Code Selection

- Soft source decoder  $\rightarrow$  LDPC source code
- Flexibly adjustable error protection power  $\rightarrow$  convolutional channel code

#### Encoding Procedure

- Source compression using channel codes is achieved by mapping long codeword sequences to short syndrome sequences.
- Convolutional codes are used to protect the syndrome bits from the noisy channel by adding redundancy bits.
- The approach of independent source and channel coding provides the flexibility of independent tuning of source and channel coding rates.

#### Decoding Procedure

- Joint iterative decoder consists of two soft sub decoders corresponding to inner convolutional code and the outer LDPC code.
- Global iteration between the inner and outer sub decoders and local message exchange within the outer sub decoder follow the turbo principle.
- Use message passing algorithm with extended H matrix for soft source decoder
- The approach of joint decoding (iterative soft decoding) maximizes the performance gain while keeping a reasonable decoding complexity

### Simulation

#### Simulation Setup

- Message sequence length  $N=2000$  bits, AWGN noisy channel
- source encoder: regular LDPC code with column weight 3
- channel encoder: 16-state convolutional code  $[1+D+D^4, 1+D^2+D^3+D^4]$

#### Compression Rate

- First, the maximum compression rate that can be supported is determined assuming perfect transmission channel
- Simulation shows that an extended LDPC code based on an  $(N,K)=(2000,1000)$  mother code achieves a BER of  $10^{-6}$  when  $p=0.0533$ .
  - $\rightarrow$  for  $p=0.0533$ , and length-2000 source sequences, a compression rate of no larger than  $\frac{1}{2}$  can be used

#### Error Resilient Capability and Joint Decoding gain

- Next, determine how much redundancy is needed for satisfactory error protection of syndrome sequences (i.e. compressed data)
- For a distortion around  $10^{-6}$ , an outer  $\frac{3}{4}$  convolutional code requires SNR=1dB
  - $\rightarrow$  the scheme achieves an overall compression rate of  $R_{outer}R_{inner} = 2/1 * 3/4 = 3:2$
- Iterative interaction between the inner sub decoder and the outer sub decoder improves the performance!

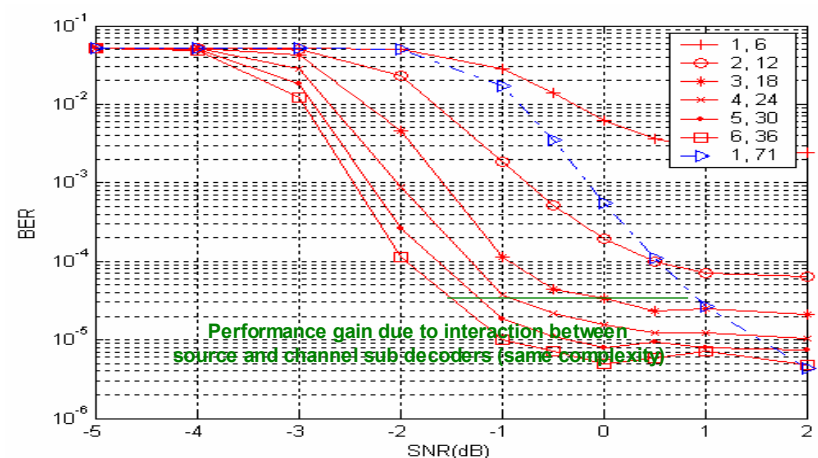


Figure 1. Performance of proposed LDPC-convolutional scheme for noisy channel DSC problem. ("g.l" in the legend refers to the total number of global and local iterations;  $p=0.0533$ ; (2000,1000) LDPC code followed by (1333,1000) convolutional code; overall compression rate 3:2.

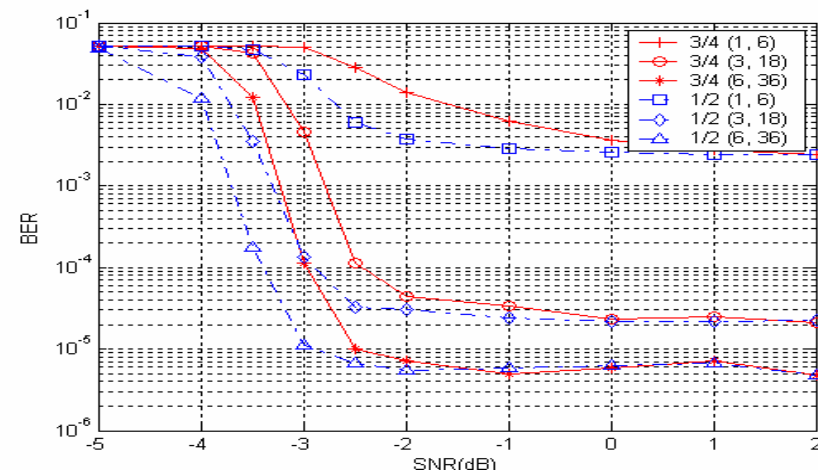


Figure 2. Performance with different error protection power. ( $p=0.0533$ ; (2000,1000) LDPC code; convolutional code rate  $\frac{1}{2}$  and  $\frac{3}{4}$ )

### Conclusion and Future Works

- A new design scheme for DSC over noisy channels (good for finite length design)
  - separate encoding  $\rightarrow$  simple, tunable
  - joint decoding  $\rightarrow$  performance gain
- Future work: irregular LDPC codes, non-perfect SI