ADAPTIVE FEEDBACK REDUCTION FOR PRECODED SPATIAL MULTIPLEXING MIMO SYSTEMS

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Abstract

We extend feedback compression schemes for precoded spatial multiplexing multiple-input multiple-output (MIMO) systems to adapt to changing channel characteristics. The presented schemes use the past feedback to estimate the conditional probability of a precoder occurrence given the last feedback at runtime. These probabilities are then used to losslessly compress the feedback.

System Model

- Spatial multiplexing MIMO system: $\mathbf{y} = \mathbf{HFs} + \boldsymbol{\nu}$
- N_T transmit antennas
- N_R receive antennas
- $N_S \leq \min(N_T, N_R)$ symbol streams
- Unitary precoder matrix $\mathbf{F} \in \mathcal{U}_{N_T \times N_S}$ is picked using a selection criterion from a codebook $\mathcal{C}$
- $\mathcal{C}$ is designed to minimize an average distortion measure
- Consider two different feedback channels
  - Dedicated feedback channel just transmits feedback
  - Non-dedicated feedback channel also transmits data

Feedback Reduction

- Feedback is encoded using source encoding techniques
  - Code for non-dedicated feedback channel must satisfy the prefix condition, e.g. Huffman code
  - Code for dedicated feedback channel does not have to fulfil the prefix condition
- The encoding is done based on the transition probabilities (Markov chain) between the actual precoders and the past precoder
- The transition probabilities at time instant t are updated based on the past trans. prob. at time instant $t-1$ as

$$P_{k,j}[t] = \frac{(N-1)P_{k,j}[t-1]+1}{N}$$

$$P_{i,j}[t] = \frac{(N-1)P_{i,j}[t-1]}{N} \quad \text{for} \quad i \neq k$$

  - $P_{k,j}$ is the probability that the actual precoder is $\mathbf{F}_k$ assuming the previous precoder was $\mathbf{F}_j$
  - N is a weighting factor

Simulations

- $N_T = 2$ antennas and $N_S = 2$ data streams
- Codebook $\mathcal{C}$ has $|\mathcal{C}| = 16$ entries
- $\mathcal{C}$ is designed using the generalized Lloyd algorithm
- Distortion measure: squared mod. Frobenius norm distance
- Selection criterion: squared mod. Frobenius norm distance
- Frame rate is fixed at $T_f = 10^{-2}s$
- Algorithm is initialized with $P_{i,j}[0] = 1/|\mathcal{C}|$ for $\forall i,j$

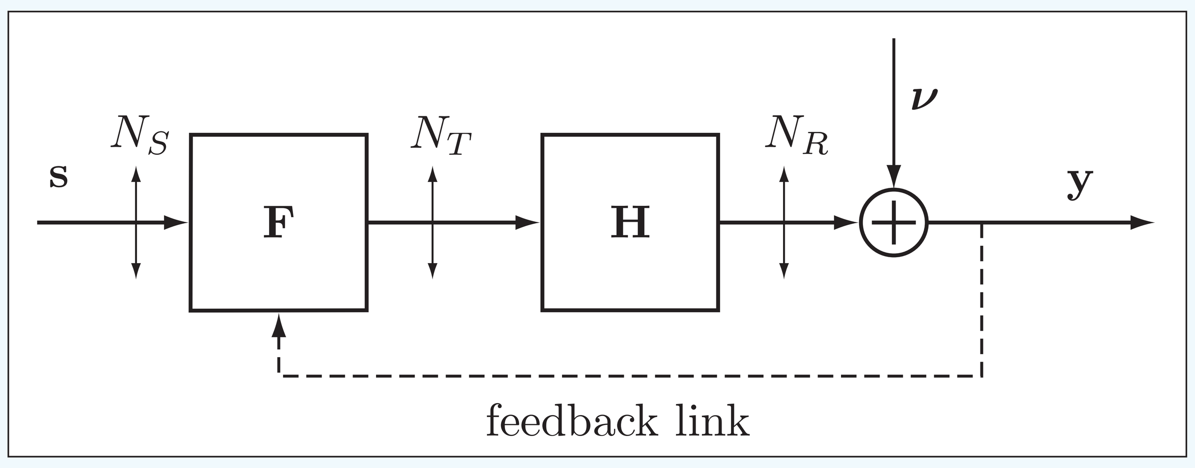

Fig. 1. System model.

Codebook	$P_{i,8}$	Huffmann Code	NPF Code
$\mathbf{F}_8$	0,25	01	/
$\mathbf{F}_2$	0,20	11	0
$\mathbf{F}_7$	0,18	000	1
$\mathbf{F}_4$	0,16	001	00
$\mathbf{F}_3$	0,10	101	01
$\mathbf{F}_6$	0,08	1000	10
$\mathbf{F}_5$	0,02	10010	11
$\mathbf{F}_1$	0,01	10011	000

Table 1. Bitwords for non-dedicated and a dedicated feedback link for the case that $\mathbf{F}'=\mathbf{F}_8$.

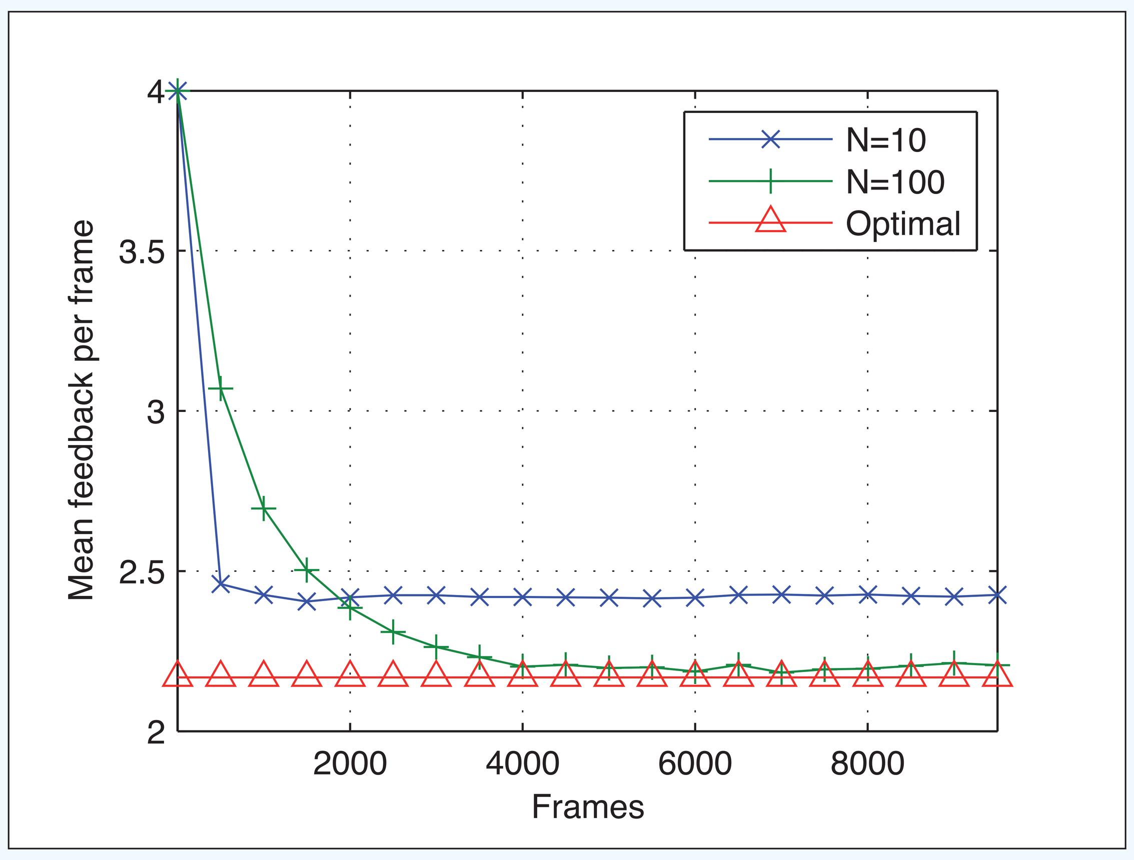

Fig. 2. Mean feedback rate per frame on a non-dedicated channel.

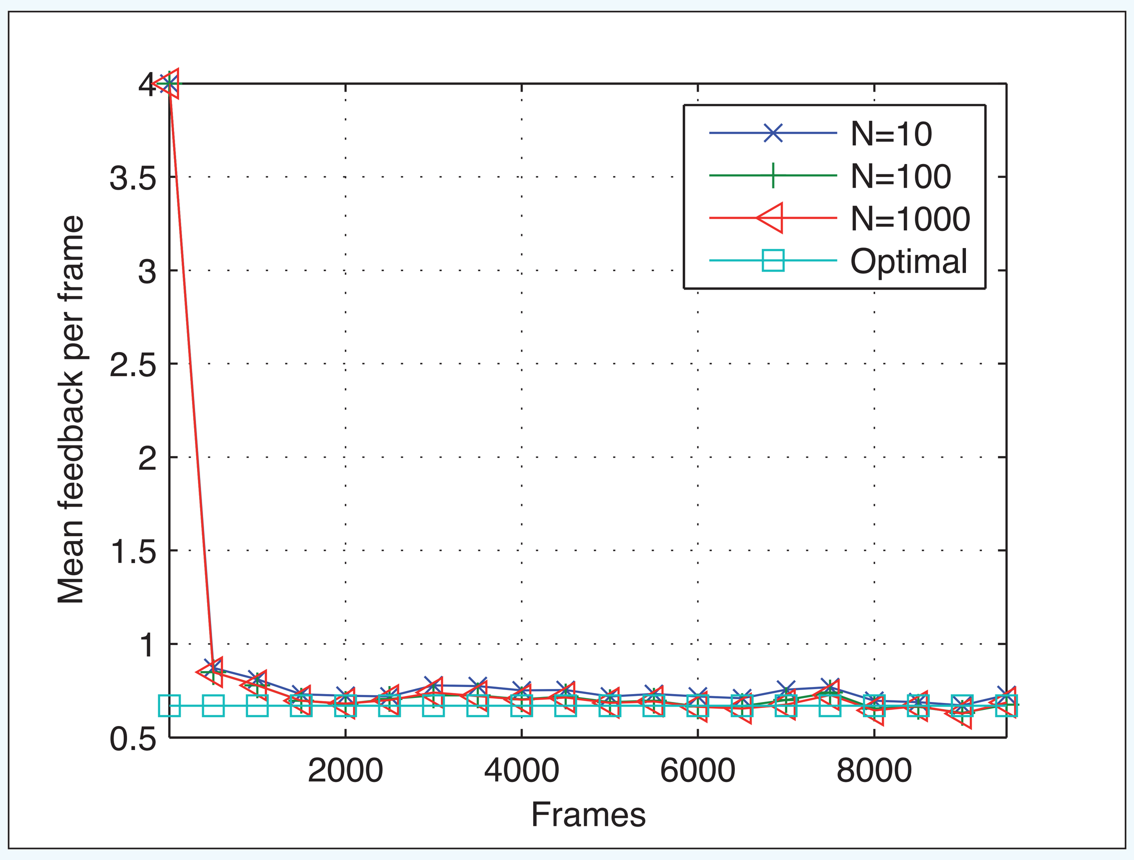

Fig. 3. Mean feedback rate per frame on a dedicated channel.

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