Sequence Optimization-based UWB Receiver
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Motivation
• Large Number of multipath components in indoor UWB channels distort received pulse shape

![Image of multipath distortion](image)

• Challenge: Maximize energy capture with a simple receiver
• Main receiver topologies:
  - Rake receiver – Large number of Rake fingers required
  - Template-assisted receiver - Noise is augmented
  - Alternative strategies:
    - Pre-Rake receiver; Rake combining at transmitter
    - Modify transmit pulse shape

Proposed Receiver
• Transmit pulse shape controlled by transmit sequence \( X \)
• Receiver template controlled by sequence \( Y \)

![Diagram of proposed receiver](image)

• Objective: Jointly optimize \( X \) and \( Y \)
• Different scenarios:
  - Single User: Maximize SNR
  - Multiple Users: Maximize SINR
  - High-power narrowband interference (NBI): Maximize SINR

Single User Case
• Objective: Maximize SNR
• Optimal transmit sequence \( X \) solves:
\[
\begin{align*}
\max_{X \in \mathbb{C}^n} & \quad Y^H H X \\
\text{subject to} & \quad X^HX = 1
\end{align*}
\]
\( H \) is the channel matrix
• Optimal \( X \) is the maximum eigenvector of \( X^H H X \)
• Optimal received sequence \( Y \) is given by
\[
Y = HX
\]

Multiple Users Case
• Objective: Maximize SINR
• \( K \) users are assumed to exist in the system
• The interference covariance matrix is
\[
Z_i = \sum_{j=1, j \neq i}^{K} H_j X_i Y_i^H + \sigma^2
\]
• Optimal received sequence \( Y \) is given by
\[
Y = Z_i^H H_i
\]
• Optimal transmit sequence \( X \) is the maximum eigenvector of \( H_i^H Z_i^H H_i \)

High Power NBI Case
• NBI modeled by data-modulated sine wave
• NBI power is 100 dB above signal power
• Sequence length = 160
• Sequence optimized for single user fails:
  - Cross-correlations from different users not taken into account
• CDMA-like system with spreading gain 160 is 1 dB away from perfect Rake
• Sequence optimized for multiuser scenario performs almost like perfect Rake in AWGN

Summary of Results
• Sequence optimization for UWB multipath channels:
  - Big gains in single user scenarios
  - Very good multiuser and NBI cancellation
  - Relatively simple receiver
  - Requires sequence feedback
  - Requires storing real-valued sequence

Relevant Publications