Channel Estimation for Wired MIMO Communication Systems

Literature Survey Presentation

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Introduction

• **MIMO** – Multiple Input Multiple Output

![MIMO Channel Diagram]

• **Wired Communications** – Telephone, ADSL, VDSL

• **Multicarrier Modulation** – DMT, OFDM

• **Channel Estimation** – 
  To estimate an unknown channel by sending a known training/pilot sequence
Data Transmission for ADSL, a wired communication system

**TRANSMITTER**

- Bits: 00110
- Multi-Modulation Encoder
- Mirror data and $N$-IFFT
- Add cyclic prefix
- P/S
- D/A + transmit filter

**RECEIVER**

- $N/2$ subchannels
- $N$ real samples
- P/S
- Decoder
- Freq. domain equalizer (invert channel)
- $N$-FFT and remove mirrored data
- S/P
- Delete cyclic prefix
- Time domain equalizer (FIR filter)
- Receive filter + A/D

**Background**

Conventional ADSL equalizer structure
Key Paper I – MIMO Channel
[A.Goldsmith, 2003]

• Why MIMO? – to obtain the higher data rate
• Challenges! – Power, Bandwidth, Complexity, Capacity
• Typical MIMO Channels – Single-User MIMO, Multiuser-MIMO (Multiple-Access Channel, Broadcast Channel)

**Channel Model**

\[ x = Hs + w \]

- \( s \) – M*1 transmitted vector
- \( H \) – N*M channel matrix
- \( x \) – N*1 received vector
- \( w \) – N*1 noise vector

MIMO with M transmitters and N receivers

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Key Paper II - Multicarrier Modulation

[John A.C. Bingham, 2000]

• Divide broadband channel into narrowband subchannels
  – No ISI in subchannels if constant gain in every subchannel and if ideal sampling
  – Each subchannel has different carrier

• Discrete multitone modulation
  – Based on fast Fourier transform
  – Orthogonal Frequency Division Multiplexing (OFDM)

Subchannels are 4.3 kHz wide in ADSL and VDSL
**Key Paper III - Channel Estimation**  
* [Ye Li, 2002]

- **OFDM** – Multicarrier Modulation for MIMO
- **Training Sequence** – Obtain initial estimation for channel parameters, timing, frequency offset, etc.
- **Channel Estimation**

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Advantage</th>
<th>Disadvantage</th>
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<tbody>
<tr>
<td><strong>Simplified Estimation</strong></td>
<td>The computational complexity ↓</td>
<td>Performance degradation but negligible</td>
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<td>[Ye Li, 2002]</td>
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<tr>
<td><strong>Linear Interpolation</strong></td>
<td>MSE on Comb-type channel estimation</td>
<td>Block-type estimator for indoor channels</td>
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<td>[Kim, Park &amp; Hong, 2005]</td>
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<td><strong>Linear Precoding</strong></td>
<td>Converges fast</td>
<td>Introduce a bias to each carrier</td>
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