Cognitive Sub-Nyquist Collocated MIMO Radar Prototype

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Main Contributions
- Prototype realizes both spatial and temporal sub-Nyquist sampling in a MIMO radar without loss of angular and range resolution
- Sub-Nyquist 4x5 MIMO array shows same detection performance as Nyquist 8x10 ULA
- Cognitive transmission is employed to further enhance SNR for sub-Nyquist arrays

Technical Specifications
<table>
<thead>
<tr>
<th>Nyquist (Mode 1)</th>
<th>Sub-Nyquist (Mode 2)</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BW per Rx (incl. guard-bands)</td>
<td>15 MHz</td>
<td>3 MHz</td>
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<tr>
<td>BW per Tx (incl. guard-bands)</td>
<td>12 MHz</td>
<td>3 MHz</td>
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<tr>
<td>Temporal sampling rate</td>
<td>30 MHz</td>
<td>7.5 MHz</td>
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<tr>
<td>Spatial sampling of Tx/Rx channels</td>
<td>8x10</td>
<td>4x5</td>
</tr>
</tbody>
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Array Modes
- Mode 1: 8x10
  - Filled uniform array
- Mode 2: 8x10
  - Filled random array
- Mode 3: 4x5
  - Thinned random array (=Virtual 8x10 ULA)
- Mode 4: 8x10
  - Thinned random array (=Virtual 20x20 ULA)

Waveform Generator
- Total BW, 8 Tx: 120 MHz 3 MHz guard-bands
- Eight 375 kHz cognitive slices per Tx
- Cognitive BW, 1 Tx: 3 MHz (= 8 x 375 kHz)
- BW reduction, 1 Tx (excl. guard-bands): 75% (3 of 12 MHz)

Analog Pre-Processor (APP)
- APP filters the receiver data into eight channels
- Dual back-to-back APPs in a single chassis
- BPFs have ~30 dB stopband attenuation to mitigate subsampling noise

Digital Receiver
- Two 16-bit eight-channel digitizers for I and Q streams
- Sub-Nyquist sampling rate: 7.5 MHz/channel
- Signal BW with guard-bands: 30 MHz/channel

Sample Measurements Results
- Randomly Placed Targets
  - Cognitive mode 3 (sub-Nyquist) detection performance is same as that of Mode 1 (Nyquist)
- Closely Placed Targets
  - Mode 4 (sub-Nyquist 8x10) has higher angular resolution than all other modes
- Cognitive Sub-Nyquist Mode
  - Cognitive mode 3 (sub-Nyquist 4x5) performs better than Nyquist in low SNR