Spectral Coexistence Via Xampling (SpeCX) Prototype

Main Contributions
- A spectrum sharing technology enabling interference-free operation of a surveillance radar and communication transmissions over a common spectrum.
- Cognitive radio (CRo) receiver blind-senses the spectrum using low sampling and processing rates.
- Cognitive radar (CRr) employs Xampling-based receiver and transmits in several narrow bands.
- We merge two systems and adapt them to solve the spectrum sharing problem.

Cognitive Radar
- Cognitive Radar based on sub-Nyquist sampling of receiver
- Leverages sub-Nyquist receiver design
- Advantage of avoiding RF interference from comm services
- Less transmit bandwidth without loss of range resolution
- All Tx power can be focused in narrower bands → high SNR

Spectral Coexistence
- The unused CRr bands can be used for comm services
- CRo blind senses multi-band comm signals
- CRo communicates vacant band information to the CRr
- CRr chooses the lowest interference sub-bands for transmission

CRo Signal Model
- Input multiband model – \( x(t) \) with Nyquist rate \( f_{Nyq} \), composed of \( 2N \) bands each with max bandwidth \( B \).
- The Modulated Wideband Converter (MWC) serves as an analog front-end: \( f \) parallel channels alias the spectrum, so that each band appears in baseband.
- Aliasing is done by mixing with periodic sequences:
  \[ x(t) = \sum_{n=-\infty}^{\infty} x_n(t) = \sum_{n=-\infty}^{\infty} \sum_{k=-\infty}^{\infty} c_{pk} \cos(2\pi f_{pk} t) \]
  \[ x_n(t) = x(t-nT) \]
  \[ f_{pk} = \frac{f_{Nyq}}{N} k \]

Sub-Nyquist Radar Model
- \( L \) targets, each defined by 3 degrees of freedom: amplitude \( a_\ell \), delay \( \tau_\ell \), and Doppler frequency \( \nu_\ell \).
- Received signal for \( P \) pulses after demodulation:
  \[ x_n(t) = \sum_{\ell=1}^{L} a_\ell \cos(2\pi f_{\tau_\ell} t + \nu_\ell t) \]

Sub-Nyquist Radar
- RF spectrum is a scarce resource and becoming increasingly crowded
- Spectral coexistence exploits spectral underutilization by allowing both radar and comm to share the same resource.

For a wideband signal Nyquist rate is not an option! → Sub-Nyquist

United States frequency allocation and spectral occupancy

Spectral Coexistence Prototype

Cognitive Radar (CRo) and Cognitive Radar (CRr) Spectral Coexistence

CRo and CRr Spectral Coexistence
- The unused CRr bands can be used for comm services
- CRo communicates vacant band information to the CRr
- CRr chooses the lowest interference sub-bands for transmission

Cognitive Radar (CRo) Prototype
- High Rate Input Signal
- Low Rate Aliased Signal
- Signal Generator
- The MWC Card
- Signal ADC + DSP

Cognitive Radar (CRr) Prototype
- System Design
- Pulse Analog Xampler
- Supporting Hardware – NI System

SpeCX Prototype and Measurement Results

SpeCX Prototype
- System Design
- Measurement Results
- CRo Reconstruction
- CRr Detections

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