COGNITIVE ANTI-JAM RADIO SYSTEM

Raghavendra S. Prabhu, Esteban L. Vallés, Philip A. Dafesh

The Aerospace Corporation

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Outline of talk

- Introduction and motivation
- Components of a CARS architecture
- Simulation results
- Conclusion

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Why is interference mitigation important?

- Spectrum is a scarce resource and contention for it can cause interference scenarios
- Sources of interference: co-channel and adjacent channel users, cognitive user that misdetected a spectral hole, adversarial jammer
- Interference and/or jamming can render link unusable and thus needs mitigation strategies
- Interference can be dynamic (not stationary) and of unknown time and frequency support
- We describe an adaptive interference mitigation strategy for single antenna (channel) DSSS signals

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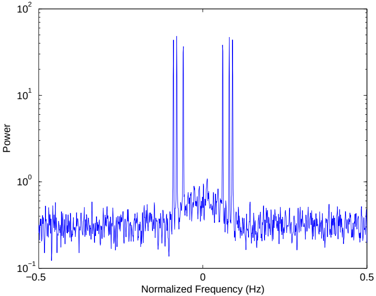
Example: Tones jamming a DSSS signal



JSR = 10 dB. Excision filtering, where the jamming signal is excised prior to demodulation, can provide good mitigation.

Prior art: Fixed Anti-Jam techniques (FATS)

- FATS such as filtering and transform domain excision techniques can provide suitable mitigation when there is prior information
- DFT transform domain excision is popular due to the low-complexity FFT algorithm and applicability to many types of interference
- Excision systems using a fixed basis (that do not adapt to the interference) will not be adequate when the interference is dynamic and changing
- Techniques exist, that consider a larger *dictionary* of basis functions, but this comes with an increased complexity
- We present a novel approach whereby the AJ signal processing first *learns* the interference and adapts both AJ mitigation and receiver signal processing

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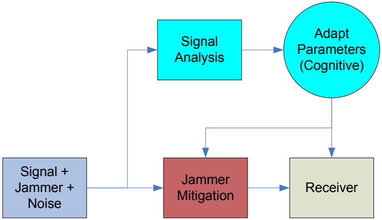
General CARS architecture



1. *Signal Analysis*: estimate characteristics of signal and jammer
2. *Adaptive jammer mitigation*: choose appropriate mitigation strategy based on jammer and signal character
3. *Adaptive receiver signal processing*: adapt receive processing to optimize performance

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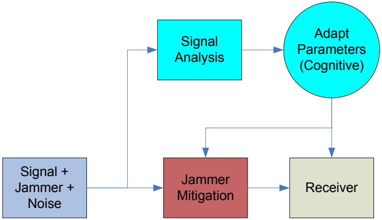

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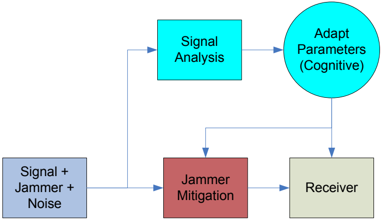

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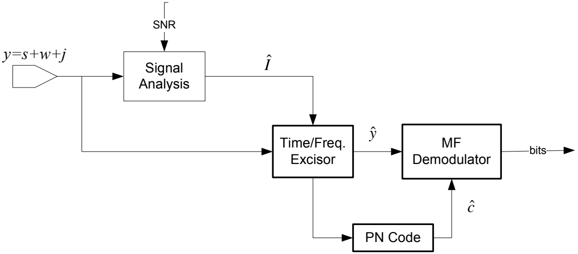
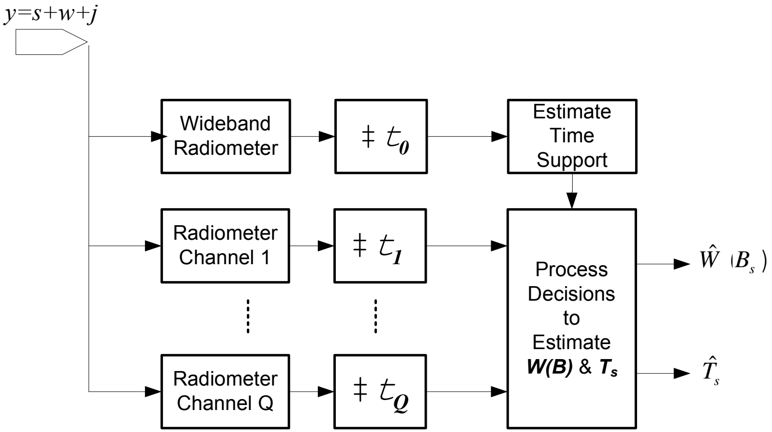
CARS architecture applied to DSSS receiver



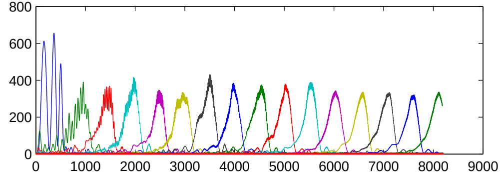
Signal model

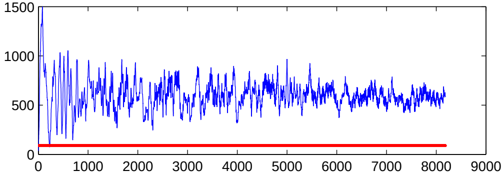
$$
\begin{aligned}
y(n) &= s(n) + j(n) + w(n) \\
&= \sqrt{\mathrm{SNR}}\; c(n)\; x_l + \sqrt{\mathrm{JSR}}\; j'(n) + w(n)
\end{aligned}
$$

Signal analyzer



Signal analyzer outputs for a chirp





Outputs of Signal analyzer

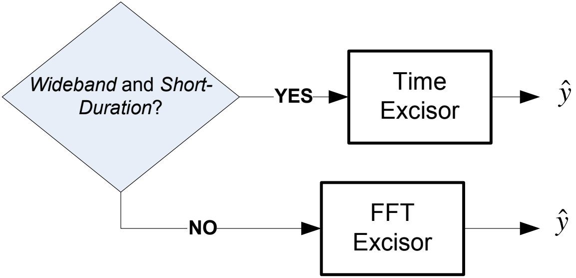
1. **Bandwidth support**: $B_s \in \{0, 1, \dots, Q\}$
2. **Time support**: $T_s \in [\Delta T, T]$

Some examples and corresponding values of B_s and T_s :

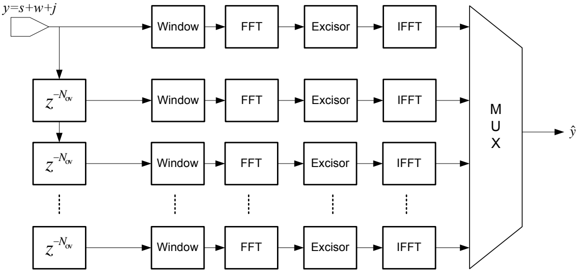
1. Impulse train interference: $B_s = Q$ and $T_s = \Delta T$
2. Single-tone continuous waveform (CW) interference: $B_s = 1$ and $T_s = T$
3. Linear chirp CW interference: $B_s = 1$ and $T_s = T/Q$

Time or Time-Frequency excision?

$$\hat{W}(B_s) = \begin{cases} 1 & \text{if } (\hat{B}_s \geq N_{\mathrm{WB}}) \ \wedge \ (\hat{T}_{\mathrm{ON}}(0) \leq N_{\mathrm{FFT,min}}); \ \ \hat{T}_s = \hat{T}_{\mathrm{ON}}(0) \\ 0 & \text{otherwise. } \ \hat{T}_s = \max \hat{T}_{\mathrm{ON}}(i) \end{cases}$$

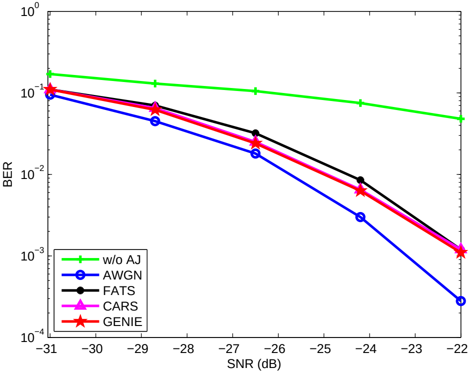


FFT excisor architecture



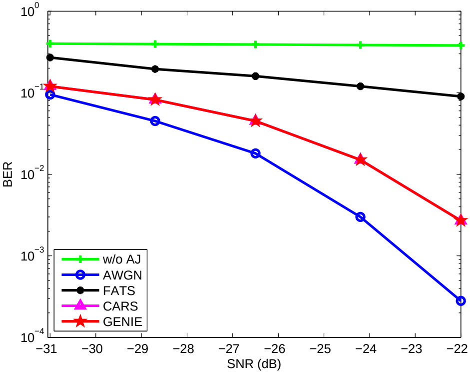
The power in each bin is compared to a threshold, τ_{FFT} and excised if the threshold is exceeded. DiPietro1989 suggests that setting the excised bins to the background noise level results in an improved performance. In this paper, for simplicity, we set excised bins to zero.

BER vs. SNR: linear chirp interference at 40 dB JSR



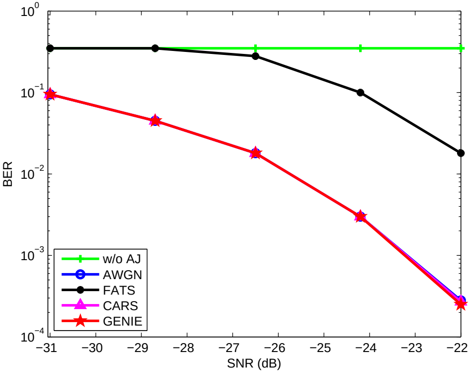
All three AJ schemes—GENIE, CARS, and FATS—exhibit similar performance

BER vs. SNR: eight-tone interference at 40 dB JSR



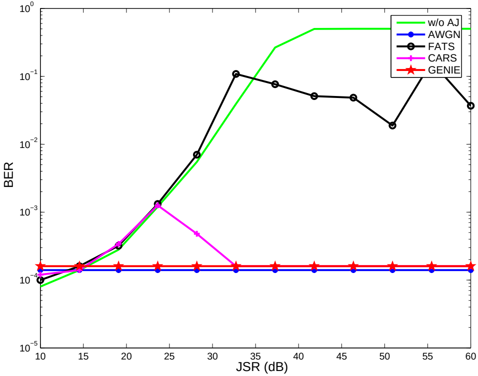
FATS performs poorly when compared to the CARS approach. Note that CARS performance is indistinguishable from GENIE.

BER vs. SNR: sixteen-impulse interference at 40 dB JSR



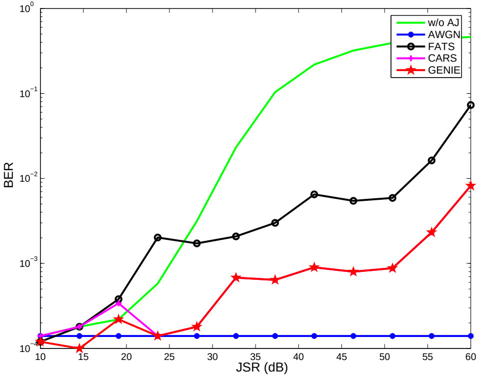
AWGN, CARS, and GENIE performances are indistinguishable from each other.

BER vs. JSR: sixteen-impulse interference at −22 dB SNR



CARS performs as well as GENIE and AWGN for most JSR

BER vs. JSR: four-tone interference at −22 dB SNR



CARS performs as well as GENIE for most JSR, and outperforms FATS

Conclusions

- introduced novel CARS approach
- a representative CARS archtecture, consisting of a bank of channelized radiometers with decision logic, time/FFT excision and adapted demodulator for DSSS system was presented
- demonstrated that CARS approach, by virtue of its adaptability (cognition), is suitable for mitigation of various types of interference
- **Open questions**
  1. determinining optimum values for the various parameters and thresholds
  2. how to determine optimal time support and excision strategy for more complex interferers
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