EXPLOITING THE CYCLOSTATIONARITY OF RADAR CHIRP SIGNALS WITH TIME-VARYING FILTERS
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• Ability to exploit time-varying cyclostationarity with TV-FRESH filter
• TV-FRESH applies weights in a periodic nature, improving upon FRESH filters
• Gives a 5 dB gain in simulated results over traditional filters

Cyclostationary Signals

\[ R_x(t, \tau) = \sum_{\alpha} R_{x, \alpha}^R(\tau) e^{j2\pi \alpha \tau}, \]

\[ R_{x, \alpha} = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} x(t + \frac{\tau}{2}) e^{j2\pi \alpha \tau} dt. \]

Cyclostationarity of Chirp Radar

\[ c(t) = \sum_{\alpha=0}^{\infty} e^{j2\pi \alpha (t - nT_c)} q(t - nT_c), \]

\[ a = \frac{\alpha}{T_c}, \quad n = 0, \pm 1, \pm 2, \ldots, \frac{T_c}{2}, \]

\[ \beta = \frac{p}{T_c}, \quad p = 0, \pm 1, \pm 2, \ldots, \frac{T_c}{2}. \]

MMSE Filter Design Equations

\[ s_{c,B-1}^c(f) = \sum_{k=0}^{B-1} \sum_{m=0}^{B-1} G_{c,B-1}(f) s_{c,B-1}^{\alpha_{c,B-1}}(f - \frac{\alpha_{c,B-1} + \alpha_{c,B-1}}{2}) s_{c,B-1}^{\alpha_{c,B-1}}(f - \frac{\alpha_{c,B-1} + \alpha_{c,B-1}}{2}), \]

\[ s_{c,1}^c(f) = \sum_{k=0}^{B-1} \sum_{m=0}^{B-1} G_{c,1}(f) s_{c,1}^{\alpha_{c,1}}(f - \frac{\alpha_{c,1} + \alpha_{c,1}}{2}) s_{c,1}^{\alpha_{c,1}}(f - \frac{\alpha_{c,1} + \alpha_{c,1}}{2}), \]

\[ p = 0, 1, \ldots, B-1; \quad k = 0, 1, \ldots, U_{c,B-1} - 1, \]

\[ m = 0, 1, \ldots, B-1; \quad n = 0, 1, \ldots, V_{c,B} - 1. \]

TV-FRESH Filter and MMSE Weight Derivation

\[ \hat{D}_{i,c}(f) = \sum_{b=0}^{B-1} \sum_{\alpha=0}^{\infty} G_{c,b+i}(f) X_{i,b}(f - \alpha_{c,b+i}) + \sum_{b=0}^{B-1} H_{c,b+i}(f) X_{i,b}(f - \beta_{c,b+i}), \]

\[ E_{i,c}(f) = D_{i,c}(f) - \hat{D}_{i,c}(f), \]

\[ E_{i,c}(f) X_{i,m}(f - \alpha_{c,m,n}) = 0, \]

\[ E_{i,c}(f) X_{i,m}(f - \beta_{c,m,n}) = 0, \]

\[ \frac{\partial}{\partial G_{c,b+i}(f)} \mathbb{E}[E_{i,c}(f) E_{i,c}^*(f)] = 0, \]

\[ \frac{\partial}{\partial H_{c,b+i}(f)} \mathbb{E}[E_{i,c}(f) E_{i,c}^*(f)] = 0. \]

2017 5th IEEE Global Conference on Signal and Information Processing November 14–16, 2017 Montreal, Canada