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

$$R_x(t,\tau) = \sum_{\alpha} R_x^{\alpha}(\tau) e^{j2\pi\alpha t},$$

$$R_x^{\alpha}(\tau) = \lim_{T\to\infty} \frac{1}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} x\left(t+\frac{\tau}{2}\right) x^*\left(t-\frac{\tau}{2}\right) e^{-j2\pi\alpha t} dt.$$

Cyclostationarity of Chirp Radar

$$c(t) = \sum_{m=-\infty}^{\infty} e^{j2\pi f_c (t-mT_c)^2} q(t-mT_c),$$

$$\alpha = \frac{n}{T_s T_c},\ n = 0, \pm 1, \pm 2, \ \ldots, \frac{T_s T_c}{2},$$

$$\beta = \frac{p}{T_s T_c},\ p = 0, \pm 1, \pm 2, \ \ldots, \frac{T_s T_c}{2}.$$

MMSE Filter Design Equations

$$S_{d_c,x_p}^{\alpha_{c,p,k}}\left(f - \frac{\alpha_{c,p,k}}{2}\right) = \sum_{b=0}^{B-1}\left[\sum_{u=0}^{U_{c,b}-1} G_{c,b,u}(f) S_{x_c,x_b}^{\alpha_{c,p,k}-\alpha_{c,b,u}}\left(f - \frac{\alpha_{c,p,k}+\alpha_{c,b,u}}{2}\right) + \sum_{v=0}^{V_{c,b}-1} H_{c,b,v}(f)\, S_{x_c,x_b^*}^{\beta_{c,b,v}-\alpha_{c,p,k}}\left(f - \frac{\beta_{c,b,v}+\alpha_{c,p,k}}{2}\right)^*\right]$$

$$S_{d_c,x_m^*}^{\beta_{c,m,n}}\left(f - \frac{\beta_{c,m,n}}{2}\right) = \sum_{b=0}^{B-1}\left[\sum_{u=0}^{U_{c,b}-1} G_{c,b,u}(f) S_{x_c,x_b^*}^{\beta_{c,m,n}-\alpha_{c,b,u}}\left(f - \frac{\beta_{c,m,n}+\alpha_{c,b,u}}{2}\right) + \sum_{v=0}^{V_{c,b}-1} H_{c,b,v}(f)\, S_{x_c,x_b}^{\beta_{c,m,n}-\beta_{c,b,v}}\left(-f + \frac{\beta_{c,m,n}+\beta_{c,b,v}}{2}\right)\right]$$

$$p = 0, 1, \ldots, B-1; \quad k = 0, 1, \ldots, U_{c,p}-1, \qquad m = 0, 1, \ldots, B-1; \quad n = 0, 1, \ldots, V_{c,m}-1.$$

TV-FRESH Filter and MMSE Weight Derivation

$$\hat{D}_{l,c}(f) = \sum_{b=0}^{B-1}\left[\sum_{u=0}^{U_{c,b}-1} G_{c,b,u}(f) X_{l,b}(f-\alpha_{c,b,u}) + \sum_{v=0}^{V_{c,b}-1} H_{c,b,v}(f) X_{l,b}^*(-f+\beta_{c,b,v})\right]$$

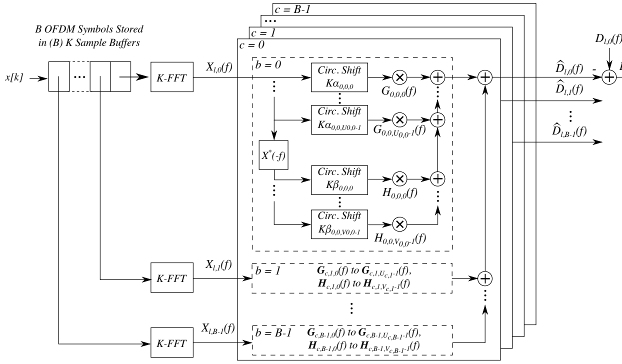
$$E_{l,c}(f) = D_{l,c}(f) - \hat{D}_{l,c}(f),$$

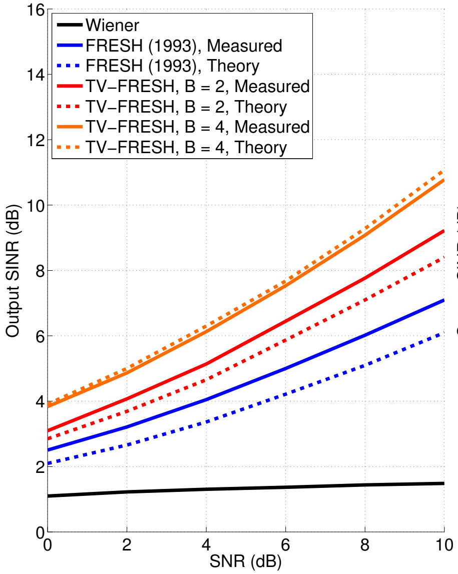
$$\mathbb{E}\left\{E_{l,c}(f) X_{l,p}^*\left(f-\alpha_{c,p,k}\right)\right\} = 0,$$

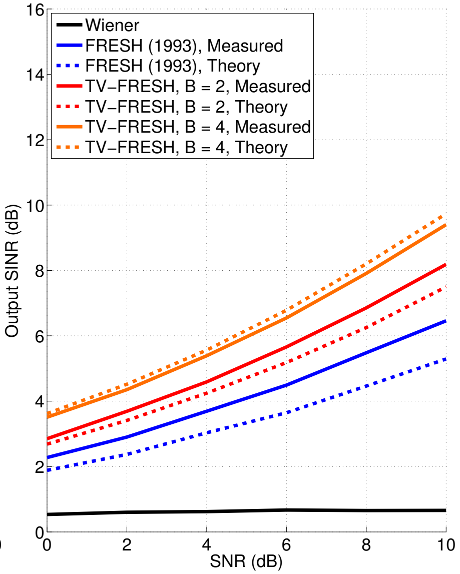
$$\mathbb{E}\left\{E_{l,c}(f) X_{l,m}\left(-f+\beta_{c,m,n}\right)\right\} = 0.$$

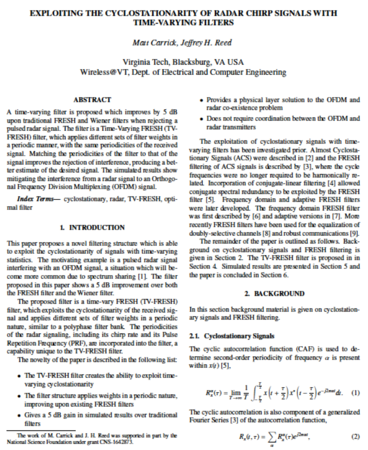
$$\frac{\partial}{\partial G_{c,p,k}^*(f)} \mathbb{E}\left\{E_{l,c}(f) E_{l,c}^*(f)\right\} = 0,$$

$$\frac{\partial}{\partial H_{c,m,n}^*(f)} \mathbb{E}\left\{E_{l,c}(f) E_{l,c}^*(f)\right\} = 0.$$





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ABSTRACT

1. INTRODUCTION

2. BACKGROUND

2.1. Cyclostationary Signals

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