$K := 220$ $\alpha := 0.015$ $\text{offset} := \frac{\pi}{180} \cdot 180$

$\text{var\_theta} := 0.1$

$K\_P := 20$

$N := 10$ $\text{saw}(x) := x - 2 \cdot \pi \cdot \text{floor}\left(\frac{x}{2 \cdot \pi} + \frac{1}{2}\right)$

$L := 1000$

$i := 0 .. K\_P - 1$

$m := 0 .. L - 1$

$k := 0 .. K - 1$

$n := 0 .. N - 1$

basisfuncties

$$\psi_{k,n} := \text{if}\left[n > 0, \sqrt{\frac{2}{K}} \cdot \cos\left[\frac{\pi \cdot n}{K} \cdot \left(k + \frac{1}{2}\right)\right], \sqrt{\frac{1}{K}}\right]$$

$$\text{index}_i := \frac{(2 \cdot i + 1) \cdot K - K\_P}{2 \cdot K\_P}$$

$$\psi\_P_{i,n} := \psi_{\left(\text{index}_i\right), n}$$

faseruis

$\text{w\_theta} := \text{rnorm}(K \cdot L, 0, 1)$

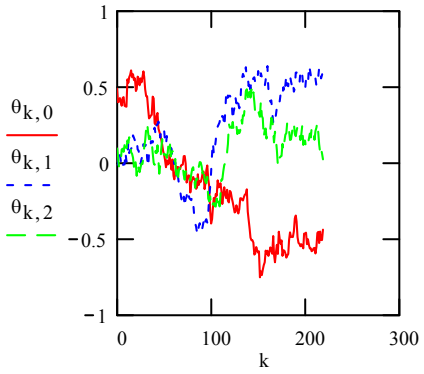
$\text{theta} := \text{rnorm}\left(L, 0, \sqrt{\text{var\_theta}}\right)$

$\theta_{0,m} := \text{theta}_m$

$$\theta_{k+1,m} := (1 - \alpha) \cdot \theta_{k,m} + \text{w\_theta}_{m \cdot K + k} \cdot \sqrt{(2 - \alpha) \cdot \alpha \cdot \text{var\_theta}}$$

schatting variantie faseruis $\frac{1}{K \cdot L} \cdot \text{tr}\left(\theta \cdot \theta^T\right) = 0.103$ $\text{var\_theta} = 0.1$

$\theta\_tot_{k,m} := \theta_{k,m} + \text{offset}$



ontvangen signaal (geen additieve ruis)

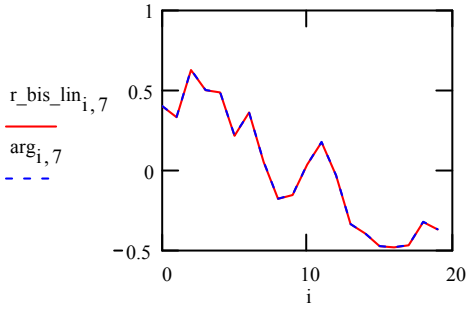
$$r\_lin_{i,m} := \theta\_tot_{index_i,m} \qquad r_{i,m} := \exp\left(j \cdot \theta\_tot_{index_i,m}\right)$$

correctie voor tijdsgemiddelde

$$r\_avg_m := \frac{1}{K\_P} \cdot \sum_i r\_lin_{i,m} \qquad arg\_avg_m := arg\left(\sum_i r_{i,m}\right)$$

$$r\_bis\_lin_{i,m} := r\_lin_{i,m} - r\_avg_m \qquad r\_bis_{i,m} := r_{i,m} \cdot \exp\left(-j \cdot arg\_avg_m\right)$$

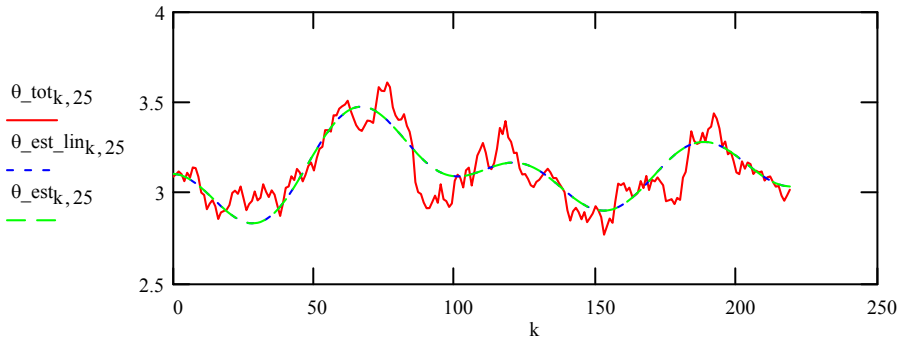
$$arg_{i,m} := arg\left(r\_bis_{i,m}\right)$$

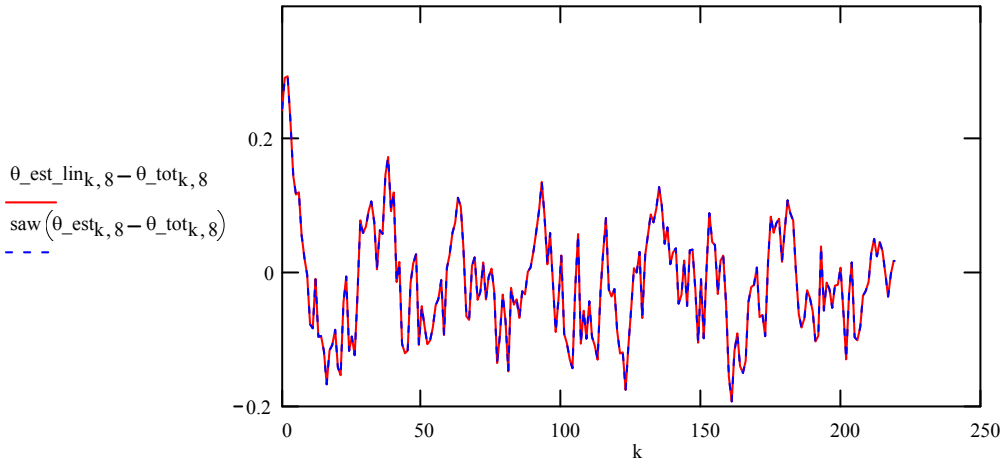


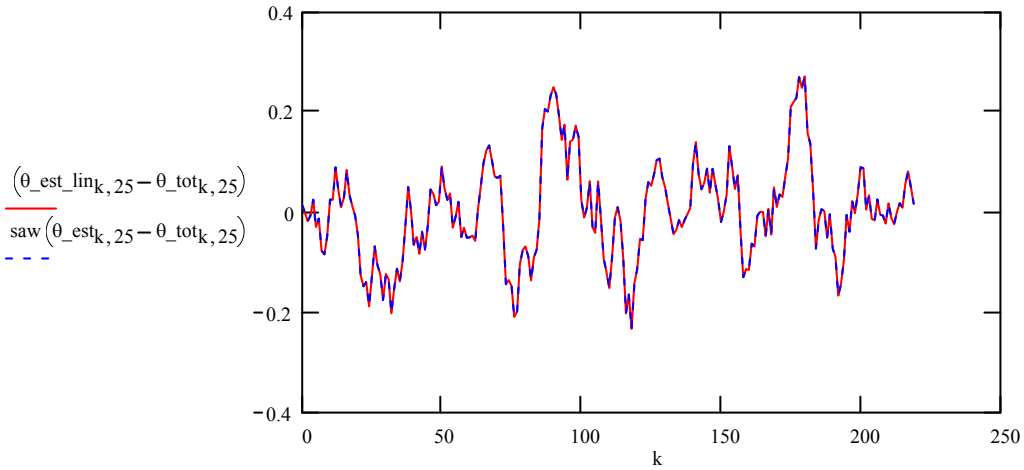
schatting

$$\theta\_est1\_lin := \left(\psi \cdot \psi\_P^T \cdot r\_bis\_lin\right) \cdot \frac{K}{K\_P} \qquad \theta\_est1 := \psi \cdot \psi\_P^T \cdot arg \cdot \frac{K}{K\_P}$$

$$\theta\_est\_lin_{k,m} := \theta\_est1\_lin_{k,m} + r\_avg_m \qquad \theta\_est_{k,m} := \theta\_est1_{k,m} + arg\_avg_m$$


θ_tot_k,25
θ_est_lin_k,25
θ_est_k,25
4
3.5
3
2.5
0
50
100
150
200
250
k


θ_est_lin_k,8 − θ_tot_k,8
saw(θ_est_k,8 − θ_tot_k,8)
0.2
0
−0.2
0
50
100
150
200
250
k


(θ_est_lin_k,25 − θ_tot_k,25)
saw(θ_est_k,25 − θ_tot_k,25)
0.4
0.2
0
−0.2
−0.4
0
50
100
150
200
250
k

$$\text{var\_est\_lin} := \frac{1}{K \cdot L} \cdot \text{tr}\left[(\theta\_\text{tot} - \theta\_\text{est\_lin}) \cdot (\theta\_\text{tot} - \theta\_\text{est\_lin})^{T} \right]$$

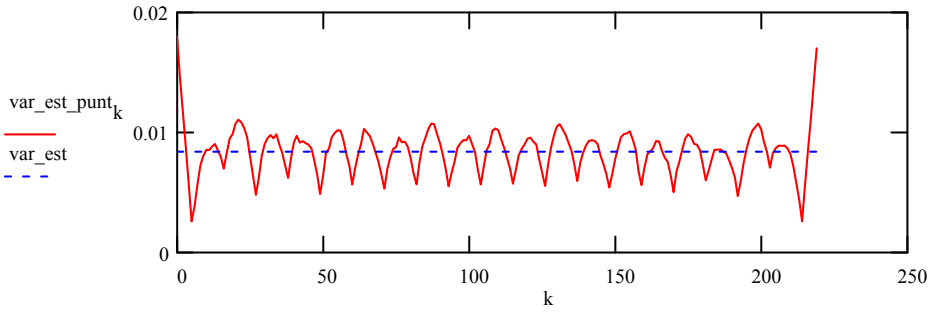
$$\text{var\_est\_lin} = 8.40245 \cdot 10^{-3}$$

$$\text{var\_est} := \frac{1}{K \cdot L} \cdot \text{tr}\left(\overrightarrow{\text{saw}(\theta\_\text{tot} - \theta\_\text{est})} \cdot \left(\overrightarrow{\text{saw}(\theta\_\text{tot} - \theta\_\text{est})} \right)^{T} \right)$$

$$\text{var\_est} = 8.40245 \cdot 10^{-3}$$

$K = 220$ $K\_P = 20$ $N = 10$ $\text{var\_theta} = 0.1$

$$\text{var\_est\_punt}_k := \frac{1}{L} \cdot \text{tr}\left[\left(\left(\overrightarrow{\text{saw}(\theta\_\text{tot} - \theta\_\text{est})} \right)^{T} \right)^{\langle k \rangle^{T}} \cdot \left(\left(\overrightarrow{\text{saw}(\theta\_\text{tot} - \theta\_\text{est})} \right)^{T} \right)^{\langle k \rangle} \right]$$



variantie over een blok wordt minimum op de posities van de pilootsymbolen