Part 2

Identification based adaptive systems

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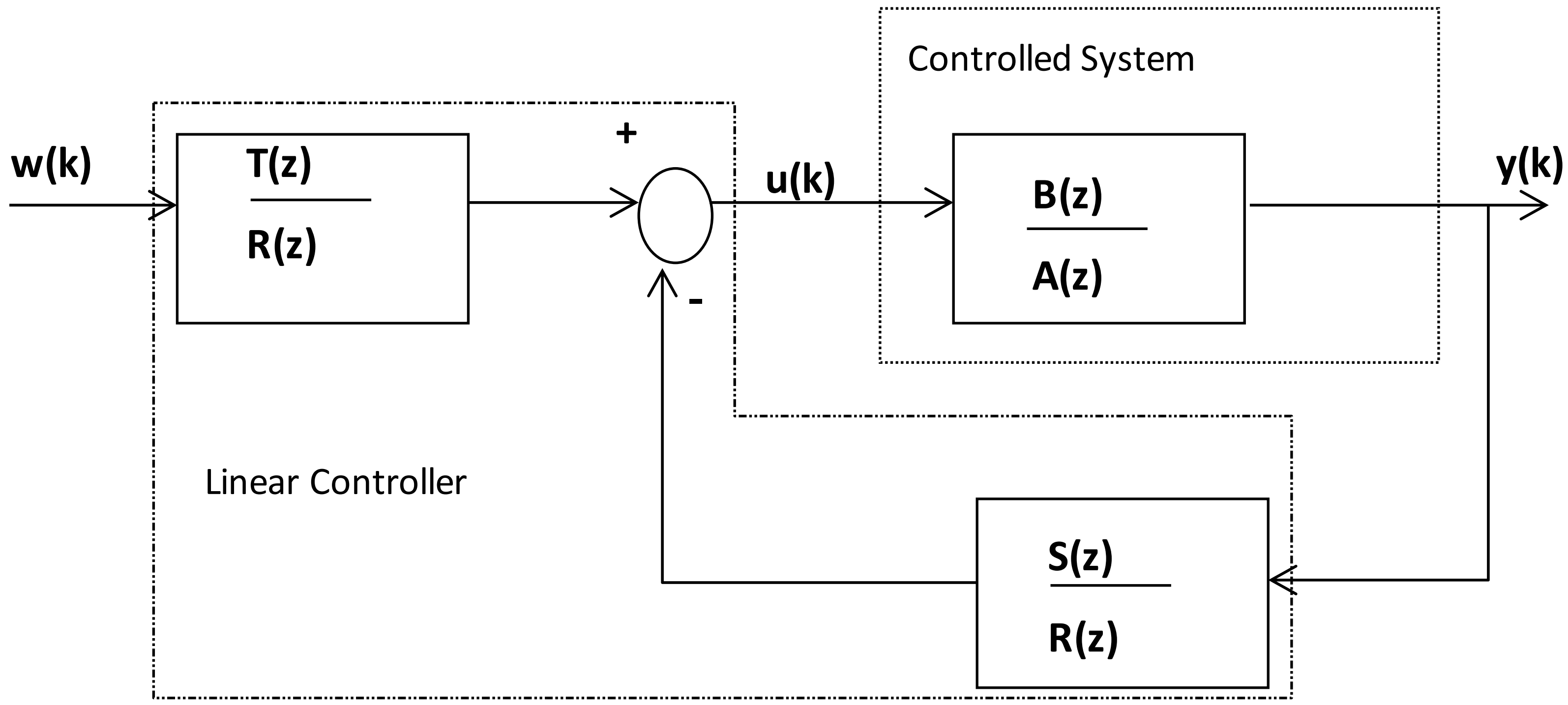
Structure of the control system



Control of a Linear System

Controlled System: $A(z)y(k)=B(z)u(k)$

Linear Controller: $R(z)u(k)=T(z)w(k)-S(z)y(k)$

Reference model: $A_m(z)y_m(z)=B_m(z)w(k)$

Closed loop system: $$y(k) = \frac{B(z)T(z)}{A(z)R(Z) + B(z)S(z)} w(k)$$

Controller design criteria:

$$\frac{\mathbf{B(z)T(z)}}{\mathbf{A(z)R(Z) + B(z)S(z)}} = \frac{\mathbf{B_m(z)}}{\mathbf{A_m(z)}}$$

Control of a 2nd order linear discrete time system

Controlled System: $A(z)= z^2+a_1z+a_2$

$B(z)= b_1z+b_2$

Reference model: $Am(z)=z^2+a_{m1}z+a_{m2} =(z-z_1) (z-z_2)$

$Bm(z)=b_{m1}z+b_{m2}$

Linear controller: $T(z)= b_{m1}/b_1z+b_{m2}/b_1$

$R(z)= z+b_2/b_1$

$S(z)= (a_{m1}-a_1) /b_1z+ (a_{m2}-a_2) /b_1$

Recurrent estimation

Data vector: $\varphi^T(k)=[-y(k-1),...,-y(k-n);\ u(k-d-1),...,u(k-d-m)]$

Parameter vector: $\hat{\Theta}^T(k-1) = \left[a_1,...,a_n;b_1,...,b_m\right]$

Model: $y(k) = \varphi^T(k)\hat{\Theta}(k-1) + e(k)$

Parameterestimation:

$$\hat{\Theta}(k) = \hat{\Theta}(k-1) + K(k)\left[y(k) - \varphi(k)\hat{\Theta}(k-1)\right]$$

$$P(k) = \frac{1}{\lambda}\left(P(k-1) - \frac{P(k-1)\varphi(k)\varphi^T(k)P(k-1)}{\lambda + \varphi^T(k)P(k-1)\varphi(k)}\right)$$

Where

$K(k)=P(k)\varphi(k)$,
$P(k)$ and **$P(k-1)$** are **$(n+m)*(n+m)$** covariance matrices of parameeter estimations,
$K(k)$ is avector of weighting coefficients,
λ ($\lambda<1$) is a memory coefficient.

2 order system's parameters estimation

Data vector: $\varphi^T(k)=[-y(k-1),-y(k-2);\ u(k-1),u(k-2)]$

Parameter vector: : $\hat{\Theta}^T(k-1)=\left[a_1,a_2;b_1,b_2\right]$

Model: $\mathbf{y(k)=\varphi^T(k)\hat{\Theta}(k-1)+e(k)}$

Parameter estimation: $\hat{\Theta}(k)=\hat{\Theta}(k-1)+K(k)\left[y(k)-\varphi(k)\hat{\Theta}(k-1)\right]$,

Here

$$\mathbf{P(k)=\frac{1}{\lambda}\left(P(k-1)-\frac{P(k-1)\varphi(k)\varphi^T(k)P(k-1)}{\lambda+\varphi^T(k)P(k-1)\varphi(k)}\right)}$$

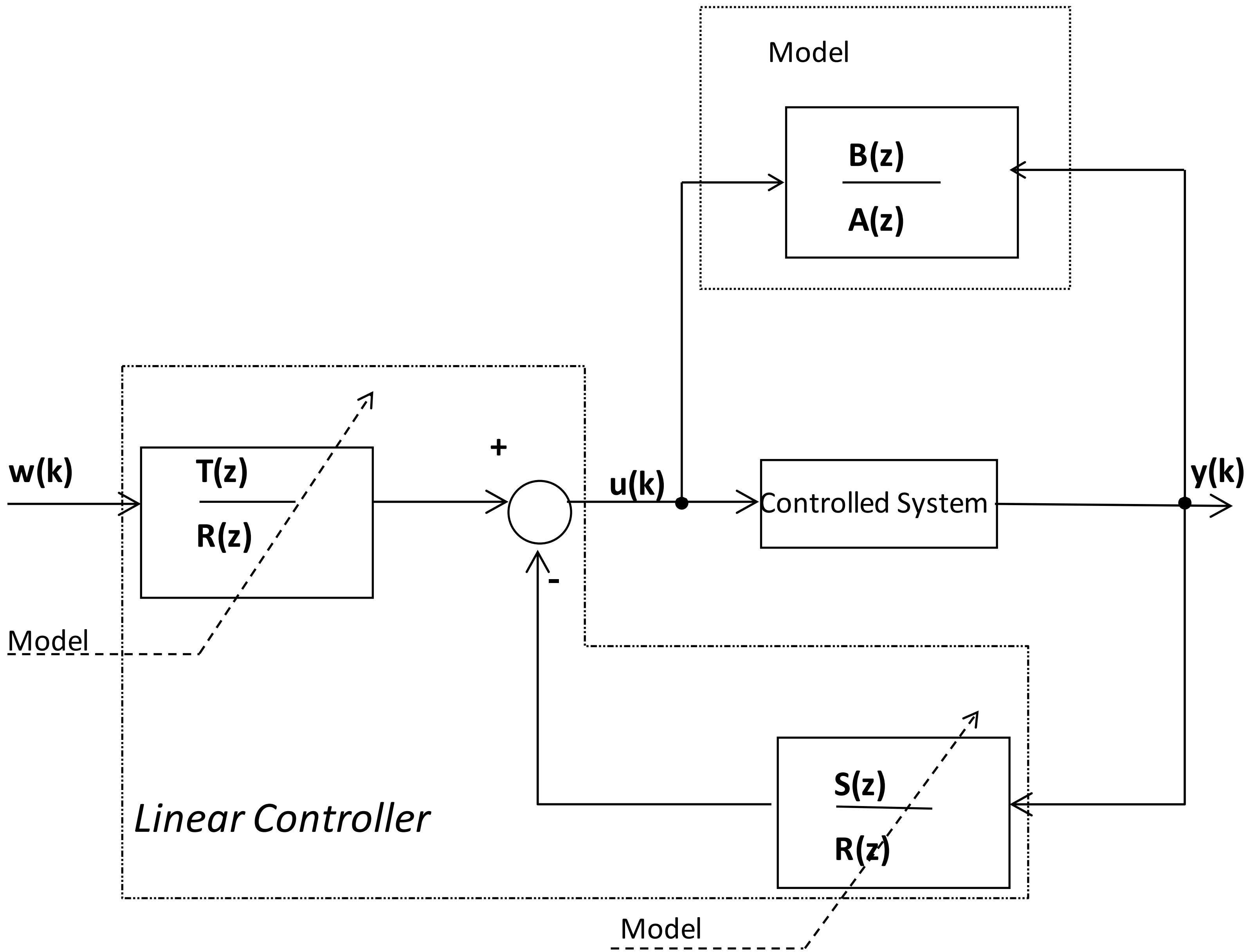
K(k)=P(k)φ(k),

P(k) and **P(k-1)** are **4x4** covariance matrices of parameeter estimations,

K(k) is avector of weighting coefficients,

λ is a memory coefficient **(λ<1)**.

Adaptive control



Test Plant

$$H(z) = \frac{z + 0.5}{z^2 - 1.5z + 0.5}$$

$$\begin{cases} a_1 = -1.5 \\ a_2 = 0.7 \\ b_1 = 1.0 \\ b_2 = 0.5 \end{cases}$$