$Y = \sum_{n=1}^{N} \Theta^n \mathrm{X}^\mathrm{n} + \Theta^0 = \sum_{\mathrm{n=0}}^{\mathrm{N}} \Theta^\mathrm{n} \mathrm{X}^\mathrm{n}$

$y(k) = \sum\limits_{i=1}^{p} a_i \left\{ \sum\limits_{l=1}^{q} d_l g_l \left[y(k-i) \right] \right\} + \sum\limits_{j=1}^{n} b1_j \left\{ \sum\limits_{t=1}^{m} c1_t f_t \left[u(k-j) \right] \right\} + \sum\limits_{j=1}^{n} b2_j \left\{ \sum\limits_{t=1}^{m} c2_t f_t \left[u(k-j) \right] \right\} + \eta(k)$

$\hat{\theta}(N) = (\Phi_N^T \Phi_N)^{-1} \Phi_N^T Y_N$

$Y_N = \Phi_N \theta$

$y(k) = \sum_{i=1}^{p} a_i \left\{ \sum_{l=1}^{q} d_l g_l \left[y(k-i) \right] \right\} + \sum_{j=1}^{n} b_j \left\{ \sum_{t=1}^{m} c_t f_t \left[u(k-j) \right] \right\} + \eta(k)$

$$\begin{aligned} \phi(k) = (&f_1[u(k-1)], ..., f_m[u(k-1)], ..., f_1[u(k-n)], ..., f_m[u(k-n)], \\ &g_1[y(k-1)], ..., g_q[y(k-1)], ..., g_1[y(k-p)], ..., g_q[y(k-p)])^T \end{aligned}$$

$\hat{\Theta}_{bc}(N) = \sum_{i=1}^{min(n,m)} \sigma_i \mu_i \nu_i^T$

$\hat{\Theta}_{ad}(N) = \sum_{i=1}^{min(p,q)} \delta_i \xi_i \zeta_i^T$

$\Phi_N = (\phi^T(1), .., \phi^T(N))$

$\theta = (b_1 c_1, ..., b_1 c_m, b_2 c_1, ..., b_2 c_m, ..., b_n c_1, ... b_n c_m, a_1 d_1, ..., a_1 d_q, ..., a_p d_1, ..., a_p d_q)^T$

$$\theta_{bc} = bc^T = \begin{pmatrix} b_1 c_1, & b_1 c_2, & ..., & b_1 c_m \\ b_2 c_1, & b_2 c_2, & ..., & b_2 c_m \\ \vdots & \vdots & \ddots & \vdots \\ b_n c_1, & b_n c_2, & ..., & b_n c_m \end{pmatrix}$$

$$\theta_{ad} = ad^T = \begin{pmatrix} a_1 d_1, & a_1 d_2, & \cdots, & a_1 d_m \\ a_2 d_1, & a_2 d_2, & \cdots, & a_2 d_m \\ \vdots & \vdots & \ddots & \vdots \\ a_n d_1, & a_n d_2, & \cdots, & a_n d_m \end{pmatrix}$$

$\hat{\beta} = (X^T X)^{-1} X^T y$

$Y_N = (y(1), ..., y(N))^T, \eta_N = (\eta(1), ..., \eta(N))^T, \Phi_N = (\phi^T(1), .., \phi^T(N))$

$Y_N = \Phi_N \theta + \eta_N$

with $\quad \Theta[\Theta^0, ..., \Theta^n] \quad , \quad X[X^0, ..., X^n]$

$$\begin{aligned} x(k) &= f(u(k)) \\ &= \sum_{t=1}^{m} c_t f_t(u(k)) \end{aligned}$$

$x(k) = f(u(k)) = \sum_{t=1}^{m} c_t f_t(u(k))$

$x1(k) = f1(u(k)) = \sum_{t=1}^{m} c1_t f1_t(u(k)), \quad x2(k) = f2(u(k)) = \sum_{t=1}^{m} c2_t f2_t(u(k))$

$$\begin{aligned} y &= g(r(k)) \\ r(k) &= g^{-1}(y(k)) \\ &= \sum_{l=1}^{q} d_l g_l(y(k)) \end{aligned}$$

$r(k) = g(y(k)) = \sum_{l=1}^{q} d_l g_l(y(k))$

$x1(k) = f1(u(k)) = \sum_{t=1}^{m} c1_t f1_t(u(k))$, $x2(k) = f2(u(k)) = \sum_{t=1}^{m} c2_t f2_t(u(k))$, $r(k) = g(y(k)) = \sum_{l=1}^{q} d_l g_l(y(k))$

$B(q) = b_0 + b_1 q^{-1} + b_2 q^{-2} + ... + b_{nb} q^{-nb}$

$y(k) = \sum_{j=1}^{n} b1_j \left\{ \sum_{t=1}^{m} c1_t f_t \left[u(k-j) \right] \right\} + \sum_{j=1}^{n} b2_j \left\{ \sum_{t=1}^{m} c2_t f_t \left[u(k-j) \right] \right\} + \sum_{i=1}^{p} a_i \left\{ \sum_{l=1}^{q} d_l g_l \left[y(k-i) \right] \right\} + \eta(k)$

$$\begin{aligned} \phi(k) = (&f_1[u(k-1)], ..., f_m[u(k-1)], ..., f_1[u(k-n)], ..., f_m[u(k-n)], \\ &f2_1[u(k-1)], ..., f2_m[u(k-1)], ..., f2_1[u(k-n)], ..., f2_m[u(k-n)], \\ &g_1[y(k-1)], ..., g_q[y(k-1)], ..., g_1[y(k-p)], ..., g_q[y(k-p)])^T \end{aligned}$$

$$\begin{aligned} &f1_i = radbas(gamma\_f1(u) * u + bias1); \\ &f2_i = radbas(gamma\_f2(u) * u + bias2); \\ &g_i = radbas(gamma\_g * y + bias3); \end{aligned}$$

$$\begin{aligned} f1_i &= radbas(gamma\_f1_i * u + bias1_i); && \text{i=(1,...,4)} \\ f2_i &= radbas(gamma\_f2_i * u + bias2_i); && \text{i=(1,...,4)} \\ g_i &= radbas(gamma\_g_i * y + bias3_i); && \text{i=(1,...,4)} \end{aligned}$$

$\Theta_{b1c1}, \Theta_{b2c2}, \Theta_{ad}$

$[U_1, S_1, V_1] = svd(\Theta_{b1c1}), [U_2, S_2, V_2] = svd(\Theta_{b2c2}), [U_3, S_3, V_3] = svd(\Theta_{ad})$

$$\begin{aligned} \hat{b1} &= S_{U1} \cdot U_1, \quad \hat{c1} = S_{U1} \cdot S_1(1,1) \cdot V_1^T; \\ \hat{b2} &= S_{U2} \cdot U_2, \quad \hat{c2} = S_{U2} \cdot S_2(1,1) \cdot V_2^T; \\ \hat{a} &= S_{U3} \cdot U_3, \quad \hat{d} \ = S_{U3} \cdot S_3(1,1) \cdot V_3^T; \end{aligned}$$

$\hat{y(k)} = \sum_{j=1}^{n} \hat{b1}_j \left\{ \sum_{t=1}^{m} \hat{c1}_t f_t \left[u(k-j) \right] \right\} + \sum_{j=1}^{n} \hat{b2}_j \left\{ \sum_{t=1}^{m} \hat{c2}_t f_t \left[u(k-j) \right] \right\} + \sum_{i=1}^{p} \hat{a}_i \left\{ \sum_{l=1}^{q} \hat{d}_l g_l \left[y(k-i) \right] \right\} + \eta(k)$

$$error = \sum_{i=1}^{n} |\hat{y} - Y_N|$$

$$m, n, p, q, \gamma_i, \sigma_i, ooo, \lambda$$

$$n, p, \gamma_i, \sigma_i, ooo, \lambda$$

$$s_{\mu 1}, s_{\mu 2}, s_{\xi}$$

$$\theta = (b_1 c_1, ..., b_1 c_m, b_2 c_1, ..., b_2 c_m, ..., b_n c_1, ...b_n c_m, b2_1 c2_1, ..., b2_1 c2_m,$$

$$indent \quad b2_2 c2_1, ..., b2_2 c_m, ..., b2_n c2_1, ...b2_n c2_m, , a_1 d_1, ..., a_1 d_q, ..., a_p d_1, ..., a_p d_q)^T$$

$$\begin{aligned}\phi(k) = (&f1_1[u(k-1)], ..., f1_m[u(k-1)], ..., f1_1[u(k-n)], ..., f1_m[u(k-n)],\\ &f2_1[u(k-1)], ..., f2_m[u(k-1)], ..., f2_1[u(k-n)], ..., f2_m[u(k-n)],\\ &g_1[y(k-1)], ..., g_q[y(k-1)], ..., g_1[y(k-p)], ..., g_q[y(k-p)])^T\end{aligned}$$

$$\begin{aligned}\theta = (&b1_1 c1_1, ..., b1_1 c_m, b1_2 c1_1, ..., b1_2 c1_m, ..., b1_n c1_1, ...b1_n c1_m, b2_1 c2_1, ..., b2_1 c2_m,\\ &b2_2 c2_1, ..., b2_2 c_m, ..., b2_n c2_1, ...b2_n c2_m, , a_1 d_1, ..., a_1 d_q, ..., a_p d_1, ..., a_p d_q)^T\end{aligned}$$

$$\begin{aligned}\theta = (&b1_1 c1_1, ..., b1_1 c_m, b1_2 c1_1, ..., b1_2 c1_m, ..., b1_n c1_1, ...b1_n c1_m,\\ &b2_1 c2_1, ..., b2_1 c2_m, b2_2 c2_1, ..., b2_2 c_m, ..., b2_n c2_1, ...b2_n c2_m,\\ &a_1 d_1, ..., a_1 d_q, a_2 d_1, ..., a_2 d_q, ..., a_p d_1, ..., a_p d_q)^T\end{aligned}$$

$$\theta_{b1c1} = b1c1^T = \begin{pmatrix} b1_1 c1_1, & b1_1 c1_2, & ..., & b1_1 c1_m \\ b1_2 c1_1, & b1_2 c1_2, & ..., & b1_2 c1_m \\ \vdots & \vdots & \ddots & \vdots \\ b1_n c1_1, & b1_n c1_2, & ..., & b1_n c1_m \end{pmatrix}$$

$$\theta_{b2c2} = b2c2^T = \begin{pmatrix} b2_1 c2_1, & b2_1 c2_2, & ..., & b2_1 c2_m \\ b2_2 c2_1, & b2_2 c2_2, & ..., & b2_2 c2_m \\ \vdots & \vdots & \ddots & \vdots \\ b2_n c2_1, & b2_n c2_2, & ..., & b2_n c2_m \end{pmatrix}$$

$$\Theta_{ad} = ad^T = \begin{pmatrix} a_1 d_1, & a_1 d_2, & \cdots, & a_1 d_m \\ a_2 d_1, & a_2 d_2, & \cdots, & a_2 d_m \\ \vdots & \vdots & \ddots & \vdots \\ a_n d_1, & a_n d_2, & \cdots, & a_n d_m \end{pmatrix}$$

$$\begin{aligned} f1_i &= radbas(\gamma 1_i, u, \sigma 1_i) \\ f2_i &= radbas(\gamma 2_i, u, \sigma 2_i) \\ g_i &= radbas(\gamma 3_i, y, \sigma 3_i) \end{aligned}$$

$$\begin{aligned} f1_i &= radbas(\gamma 1_i, u, \sigma 1_i); \quad \text{(i=1,...,4)} \\ f2_i &= radbas(\gamma 2_i, u, \sigma 2_i); \quad \text{(i=1,...,4)} \\ g_i &= radbas(\gamma 3_i, y, \sigma 3_i); \quad \text{(i=1,...,4)} \end{aligned}$$

$\hat{b1}, \hat{c1}, \hat{b2}, \hat{c2}, \hat{a}, \hat{d}$

$error = \sum_{i=1}^{n} |\hat{y} - Y_N|$

$\mathbf{error = \sum_{k=1}^{N} |y(\hat{k}) - y(k)|}$

$$\begin{aligned}
\mathbf{f1_i} &= \mathbf{radbas}(\gamma\mathbf{1_i}, \mathbf{u}, \sigma\mathbf{1_i}) \\
\mathbf{f2_i} &= \mathbf{radbas}(\gamma\mathbf{2_i}, \mathbf{u}, \sigma\mathbf{2_i}) \\
\mathbf{g_i} &= \mathbf{radbas}(\gamma\mathbf{3_i}, \mathbf{y}, \sigma\mathbf{3_i})
\end{aligned}$$

$$\begin{aligned}
f1_i &= radbas(\gamma 1_i, u, \beta 1_i) \\
f2_i &= radbas(\gamma 2_i, u, \beta 2_i) \\
g_i &= radbas(\gamma 3_i, y, \beta 3_i)
\end{aligned}$$

$$\begin{aligned}
\hat{\Theta}_{b1c1}(N) &= \sum_{i=1}^{min(n,m)} \sigma 1_i \mu 1_i \nu 1_i^T, \\
\hat{\Theta}_{b2c2}(N) &= \sum_{i=1}^{min(n,m)} \sigma 2_i \mu 2_i \nu 2_i^T, \\
\hat{\Theta}_{ad}(N) &= \sum_{i=1}^{min(p,q)} \delta_i \xi_i \zeta_i^T
\end{aligned}$$

$$\begin{aligned}
\hat{b1}(N) &= s_{\mu 1} \mu 1_1, \quad \hat{c1}(N) = s_{\mu 1} \sigma 1_1 \nu 1_1 \\
\hat{b2}(N) &= s_{\mu 2} \mu 2_1, \quad \hat{c2}(N) = s_{\mu 2} \sigma 2_1 \nu 2_1
\end{aligned}$$

$\hat{a}(N) = s_\xi \xi_1, \quad \hat{d}(N) = s_\xi \delta_1 \zeta_1$

$y(k) = \Phi^T(k)\theta + \eta(k)$

$$\begin{aligned}
\theta = (&b_1c_1, ..., b_1c_m, b_2c_1, ..., b_2c_m, ..., b_nc_1, ...b_nc_m, b2_1c2_1, ..., b2_1c2_m, \\
&b2_2c2_1, ..., b2_2c_m, ..., b2_nc2_1, ...b2_nc2_m, a_1d_1, ..., a_1d_q, ..., a_pd_1, ..., a_pd_q)^T \\
= (&\theta_1, ...\theta_{nm}, \theta_{nm+1}, ..., \theta_{2nm}, \theta_{2nm+1}, ..., \theta_{2nm+pq})^T
\end{aligned}$$

$$y(k)=\sum_{j=1}^{n} b1_j \left\{\sum_{t=1}^{m} c1_t f1_t\left[u(k-j)\right]\right\}+\sum_{j=1}^{n} b2_j \left\{\sum_{t=1}^{m} c2_t f2_t\left[u(k-j)\right]\right\}+\sum_{i=1}^{p} a_i \left\{\sum_{l=1}^{q} d_l g_l\left[y(k-i)\right]\right\}+$$
$$\eta(k)$$

$$\begin{aligned} f1_i &= exp(-(\gamma 1_i \cdot u+\sigma 1_i)^2); \quad \text{(i=1,...,4)} \\ f2_i &= exp(-(\gamma 2_i \cdot u+\sigma 2_i)^2); \quad \text{(i=1,...,4)} \\ g_i &= exp(-(\gamma 3_i \cdot y+\sigma 3_i)^2); \quad \text{(i=1,...,4)} \end{aligned}$$

$$\begin{aligned} f1_t(u(k)) &= exp(-(\gamma 1_t \cdot (u(k)+\beta 1_t))^2); \quad \text{(t=1,...,4)} \\ f2_t(u(k)) &= exp(-(\gamma 2_t \cdot (u(k)+\beta 2_t))^2); \quad \text{(t=1,...,4)} \\ g_l(y(k)) &= exp(-(\gamma 3_l \cdot (y(k)+\beta 3_l))^2); \quad \text{(l=1,...,4)} \end{aligned}$$

$\hat{\Theta}_{b1c1}, \hat{\Theta}_{b2c2}, , \hat{\Theta}_{ad}$

$$\theta_{ad}=ad^T=\begin{pmatrix} a_1d_1, & a_1d_2, & \cdots, & a_1d_q \\ a_2d_1, & a_2d_2, & \cdots, & a_2d_q \\ \vdots & \vdots & \ddots & \vdots \\ a_pd_1, & a_pd_2, & \cdots, & a_pd_q \end{pmatrix}$$

$$\hat{\Theta}_{b1c1}=b1c1^T=\begin{pmatrix} b1_1c1_1, & b1_1c1_2, & ..., & b1_1c1_m \\ b1_2c1_1, & b1_2c1_2, & ..., & b1_2c1_m \\ \vdots & \vdots & \ddots & \vdots \\ b1_nc1_1, & b1_nc1_2, & ..., & b1_nc1_m \end{pmatrix},$$

$$\hat{\Theta}_{b2c2}=b2c2^T=\begin{pmatrix} b2_1c2_1, & b2_1c2_2, & ..., & b2_1c2_m \\ b2_2c2_1, & b2_2c2_2, & ..., & b2_2c2_m \\ \vdots & \vdots & \ddots & \vdots \\ b2_nc2_1, & b2_nc2_2, & ..., & b2_nc2_m \end{pmatrix}$$

$$\Theta_{ad}=ad^T=\begin{pmatrix} a_1d_1, & a_1d_2, & \cdots, & a_1d_q \\ a_2d_1, & a_2d_2, & \cdots, & a_2d_q \\ \vdots & \vdots & \ddots & \vdots \\ a_pd_1, & a_pd_2, & \cdots, & a_pd_q \end{pmatrix}$$

$$\hat{\Theta}_{b1c1}=\hat{b1}\hat{c1}^T=\begin{pmatrix} \widehat{b1_1c1_1}, & \widehat{b1_1c1_2}, & ..., & \widehat{b1_1c1_m} \\ \widehat{b1_2c1_1}, & \widehat{b1_2c1_2}, & ..., & \widehat{b1_2c1_m} \\ \vdots & \vdots & \ddots & \vdots \\ \widehat{b1_nc1_1}, & \widehat{b1_nc1_2}, & ..., & \widehat{b1_nc1_m} \end{pmatrix},$$

$$\hat{\Theta}_{b2c2}=\hat{b2}\hat{c2}^T=\begin{pmatrix} \widehat{b2_1c2_1}, & \widehat{b2_1c2_2}, & ..., & \widehat{b2_1c2_m} \\ \widehat{b2_2c2_1}, & \widehat{b2_2c2_2}, & ..., & \widehat{b2_2c2_m} \\ \vdots & \vdots & \ddots & \vdots \\ \widehat{b2_nc2_1}, & \widehat{b2_nc2_2}, & ..., & \widehat{b2_nc2_m} \end{pmatrix},$$

$$\hat{\Theta}_{ad} = \hat{a}\hat{d}^T = \begin{pmatrix} \widehat{a_1 d_1}, & \widehat{a_1 d_2}, & \cdots, & \widehat{a_1 d_q} \\ \widehat{a_2 d_1}, & \widehat{a_2 d_2}, & \cdots, & \widehat{a_2 d_q} \\ \vdots & \vdots & \ddots & \vdots \\ \widehat{a_p d_1}, & \widehat{a_p d_2}, & \cdots, & \widehat{a_p d_q} \end{pmatrix}$$

$$y(\hat{k}) = \sum_{j=1}^{n} \hat{b_{1j}} \left\{ \sum_{t=1}^{m} \hat{c}_{1t} f_t \left[u(k-j) \right] \right\} + \sum_{j=1}^{n} \hat{b_{2j}} \left\{ \sum_{t=1}^{m} \hat{c}_{2t} f_t \left[u(k-j) \right] \right\} + \sum_{i=1}^{p} \hat{a}_i \left\{ \sum_{l=1}^{q} \hat{d}_l g_l \left[y(k-i) \right] \right\} + \eta(k)$$

$$f_{1t}(u(k)) = exp(-(\gamma_{1t} \cdot (u(k) + \beta_{1t}))^2); \quad \text{(t=1,...,4)}$$
$$f_{2t}(u(k)) = exp(-(\gamma_{2t} \cdot (u(k) + \beta_{2t}))^2); \quad \text{(t=1,...,4)}$$
$$g_{3l}(y(k)) = exp(-(\gamma_{3l} \cdot (y(k) + \beta_{3l}))^2); \quad \text{(l=1,...,4)}$$