

APÉNDICE A

Programas

En el presente apéndice se muestran los programas en MATLAB® utilizados para realizar las simulaciones.

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%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%  
%% Estimadores (digitales) con adaptación.  
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close all, clear all, clc;
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n=3000; t=0:n-1;  
a = 0.3; b = 0.07; c = 0.05; d = 0.06;
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for i=1:n  
    w(i) = b*randn;  
    v(i) = c*randn;  
end
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```
y(1)=0.05;  
B0(1)=0; at0(1)=0.5; yt0(1)=0.05; e0(1)=0.002; J0(1)=0.003; adap0(1)=0;  
Q1(1)=0; at1(1)=0.5; yt1(1)=0.05; e1(1)=0.002; J1(1)=0.003; adap1(1)=0;  
Q2(1)=0; at2(1)=0.5; yt2(1)=0.05; e2(1)=0.002; J2(1)=0.003; adap2(1)=0;  
Q3(1)=0; at3(1)=0.5; yt3(1)=0.05; e3(1)=0.002; J3(1)=0.003; adap3(1)=0;
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```
att0(1)=0.05; ytt0(1)=0.03; ee0(1)=0.002; Jx0(1)=0.003;  
att1(1)=0.05; ytt1(1)=0.03; ee1(1)=0.002; Jx1(1)=0.003;  
att2(1)=0.05; ytt2(1)=0.03; ee2(1)=0.002; Jx2(1)=0.003;  
att3(1)=0.05; ytt3(1)=0.03; ee3(1)=0.002; Jx3(1)=0.003;
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Kp=0.25; Ki=0.03; Kd=0.0025;  
e3t(1)=0;
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```
for k=2:n  
    wt(k) = - a*v(k-1) + w(k) + v(k);  
    y(k) = a*y(k-1) + wt(k);    %% Sistema de referencia.  
    %% -----
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```
    B0(k) = y(k-1)*y(k-1) + B0(k-1);  
    Q1(k) = 1/k * (y(k-1)*y(k-1) + (k-1)*Q1(k-1));  
    Q2(k) = 1/k * (y(k-1)*y(k-1) + (k-1)*Q2(k-1));  
    Q3(k) = 1/k * (y(k-1)*y(k-1) + (k-1)*Q3(k-1));
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at0(k) = at0(k-1)*B0(k-1)/B0(k) + y(k)*y(k-1)/B0(k);
at1(k) = at1(k-1)*(k-1)*Q1(k-1)/(k*Q1(k)) + y(k)*y(k-1)/(k*Q1(k));
at2(k) = at2(k-1)*(k-1)*Q2(k-1)/(k*Q2(k)) + y(k)*y(k-1)/(k*Q2(k));
at3(k) = at3(k-1)*(k-1)*Q3(k-1)/(k*Q3(k)) + y(k)*y(k-1)/(k*Q3(k));

yt0(k) = at0(k)*yt0(k-1) + wt(k);
yt1(k) = at1(k)*yt1(k-1) + wt(k);
yt2(k) = at2(k)*yt2(k-1) + wt(k);
yt3(k) = at3(k)*yt3(k-1) + wt(k);

e0(k) = y(k) - yt0(k);
e1(k) = y(k) - yt1(k);
e2(k) = y(k) - yt2(k);
e3(k) = y(k) - yt3(k);

J0(k) = 1/k * (e0(k)*e0(k) + (k-1)*J0(k-1));
J1(k) = 1/k * (e1(k)*e1(k) + (k-1)*J1(k-1));
J2(k) = 1/k * (e2(k)*e2(k) + (k-1)*J2(k-1));
J3(k) = 1/k * (e3(k)*e3(k) + (k-1)*J3(k-1));

adap0(k) = sign(e0(k))*J0(k);
adap1(k) = sign(e1(k))*J1(k);
adap2(k) = -sign(e2(k))*J2(k)/(k*Q2(k));
adap3(k) = Kp*e3(k) + Ki*( e3t(k-1) ) + Kd*( e3(k) - e3(k-1) );

e3t(k) = e3t(k-1) + e3(k);

att0(k) = att0(k-1)*B0(k-1)/B0(k) + y(k)*y(k-1)/B0(k) + adap0(k);
att1(k) = att1(k-1)*(k-1)*Q1(k-1)/(k*Q1(k)) + y(k)*yt1(k-1)/(k*Q1(k)) + adap1(k);
att2(k) = att2(k-1)*(k-1)*Q2(k-1)/(k*Q2(k)) + y(k)*yt2(k-1)/(k*Q2(k)) + adap2(k);
att3(k) = att3(k-1)*(k-1)*Q3(k-1)/(k*Q3(k)) + y(k)*yt3(k-1)/(k*Q3(k)) + adap3(k);

ytt0(k) = att0(k)*ytt0(k-1) + wt(k); %% Producto punto.
ytt1(k) = att1(k)*ytt1(k-1) + wt(k); %% Modos deslizantes.
ytt2(k) = att2(k)*ytt2(k-1) + wt(k); %% Modos deslizantes con velocidad de cambio.
ytt3(k) = att3(k)*ytt3(k-1) + wt(k); %% PID.

ee0(k) = y(k) - ytt0(k);
ee1(k) = y(k) - ytt1(k);
ee2(k) = y(k) - ytt2(k);
ee3(k) = y(k) - ytt3(k);

Jx0(k) = 1/k * (ee0(k)*ee0(k) + (k-1)*Jx0(k-1));
Jx1(k) = 1/k * (ee1(k)*ee1(k) + (k-1)*Jx1(k-1));
Jx2(k) = 1/k * (ee2(k)*ee2(k) + (k-1)*Jx2(k-1));
Jx3(k) = 1/k * (ee3(k)*ee3(k) + (k-1)*Jx3(k-1));

```

end

```

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%% Gráficas.
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

figure; %% 1
plot(t,wt,'-');
    title('Señal de entrada: w(k)');
    legend('w(k)');
    grid on;

figure; %% 2
plot(t,y,'-');
    title('Respuesta del sistema: y(k)');
    legend('y(k)');
    grid on;

figure; %% 3
plot(t,y,'-',t,yt1,'-.');
    title('Comparación de señales: y(k), yt(k)');
    legend('y(k)', 'yt(k)');
    grid on;

figure; %% 4
plot(t,at1,'-');
    title('Estimación del parámetro interno: at(k)');
    legend('at(k)');
    grid on;

figure; %% 5
plot(t,e1,'-');
    title('Error: e_1(k) := y(k) - yt(k)');
    legend('e_1(k)');
    grid on;

figure; %% 6
plot(t,J1,'-');
    title('Funcional del error: J_1(k)');
    legend('J_1(k)');
    grid on;

figure; %% 7
plot(t,y,'-',t,ytt1,'-.');
    title('Comparación de señales: y(k), ytt(k)');
    legend('y(k)', 'ytt(k)');
    grid on;

figure; %% 8
plot(t,att1,'-');
    title('Estimación del parámetro interno: att(k)');
    legend('att(k)');
    grid on;

```

