Systems and Control Engineering
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MATLAB Course for Master Students

Exercise

We will in this exercise try to obtain a weather model which may be used for predicting the daily mean temperature from known daily meteorological data, here only the mean temperature and daily mean pressure are used. Define the following variables

- T_k - daily mean temperature, $[^\circ C]$
- P_k - daily mean pressure $[mBar]$.

We have observed daily values (time series) for T_k and P_k and organized those data into data matrices as follows

$$Y = \begin{bmatrix} T_1 \\ T_2 \\ \vdots \\ T_N \end{bmatrix}, \quad U = \begin{bmatrix} P_1 \\ P_2 \\ \vdots \\ P_N \end{bmatrix} \tag{1}$$

The meteorological data are stored on the ascii-file **tp_dat.txt**.

a) Use MATLAB. Use the **load** MATLAB command and load the time series data in the file **tp_dat.txt** into MATLAB.

```
>> load tp_dat.txt
```

1. Find the number of observed data points N by using the MATLAB **size** function.
2. Define Y and U from the data in the file **tp_dat.txt**.
3. Plot the mean temperature, Y, and the mean pressure, P, in separate MATLAB figures.

b) Download the **d-sr.zip** file from internet, i.e. from the web page

`http://www2.hit.no/tf/fag/a2202/`

Follow the given instructions and install the D-SR Toolbox for MATLAB on your computer.

c) Use the **dsr** subspace system identification function in the D-SR Toolbox and identify a prediction Kalman filter model of the form

$$\begin{aligned} \bar{x}_{k+1} &= Ax_k + Bu_k + K(y_k - \bar{y}_k) && (2) \\ \bar{y}_k &= D\bar{x}_k && (3) \end{aligned}$$

with given (known) initial predicted state $\bar{x}_1$.

Simulate the model and plot the predicted daily mean temperature $\bar{y}_k$ in the same figure as the actual temperature.

d) Assume know that only the daily temperatures are known and use only the temperature time series in order to identify a stochastic prediction model of the form

$$\begin{aligned} \bar{x}_{k+1} &= Ax_k + K(y_k - \bar{y}_k) && (4) \\ \bar{y}_k &= D\bar{x}_k && (5) \end{aligned}$$

with given (known) initial predicted state $\bar{x}_1$.

Use the **dsr_s** function in order to construct the model.

Simulate the model and plot the predicted daily mean temperature $\bar{y}_k$ in the same figure as the actual temperature.

e) Compare the results in step c) and d) above. Make some comment upon the results.

1 MATLAB solution scripts

```
clear all

load test4.txt

Y=test4(:,1);     % Mean daily temperature
U=test4(:,4);     % Mean daily pressure

N=length(Y);      % Number of observations

Nid=floor(2*N/3); % Number of observations used for the identification

Yid=Y(1:Nid); Uid=U(1:Nid);          % Identification data

% DSR
[A,B,D,E,C,F,x0]=dsr(Yid,Uid,5,0);

Ypred_dsr=dsropt(A,B,D,E,C,F,Y,U,x0);
std(Y-Ypred_dsr)

% DSR_s
[a,d,c,f,x0s]=dsr_s(Yid,5);
Ks=c*pinv(f);
xs=x0s;
for k=1:N
    ys=d*xs;
    Ypred_dsrs(k,1)=ys;
    xs=a*xs+Ks*(Y(k)-ys);
end
std(Y-Ypred_dsrs)

% OLS
X=[Uid ones(Nid,1)];
B_ols= inv(X'*X)*X'*Yid;
Y_ols=[U ones(N,1)]*B_ols;


figure(1)
subplot(211), plot([Y Ypred_dsr])
grid
Title('Actual and predicted daily mean temperature: (combined det. and stoc. model)')
xlabel('Day number')
subplot(212), plot(Y-Ypred_dsr)

figure(2)
plot([Y Ypred_dsrs])
```

```
grid
Title('Actual and predicted daily mean temperature: (stochastic model)')
xlabel('Day number')
```