Example 21.5 Fitting Linear Models

File: `Ch21_E05.m`

Fitting linear relationships to experimental data is one of the basic tools for laboratory data analysis. This script demonstrates a simple approach using Matlab.

Contents

Data

The sample data comes from Example 21.5 of Seborg, et al. The first column is the biological oxygen demand (BOD) and the second column is solids concentration (mg/liter) for a series of daily samples of the effluent of a waste water treatment plant.

```
data = [ ...
    17.7    1380;
    23.6    1458;
    13.2    1322;
    25.2    1448;
    13.1    1334;
    27.8    1485;
    29.8    1503;
     9.0    1540;
    14.3    1341;
    26.0    1448;
    23.2    1426;
    22.8    1417;
    20.4    1384;
    17.5    1380;
    18.4    1396;
    16.8    1345;
    13.8    1349;
    19.4    1398;
    24.7    1426;
    16.8    1361;
    14.9    1347;
    27.6    1476;
    26.1    1454;
    20.0    1393;
    22.9    1427;
    22.4    1431;
    19.6    1405;
    31.5    1521;
    19.9    1409;
```

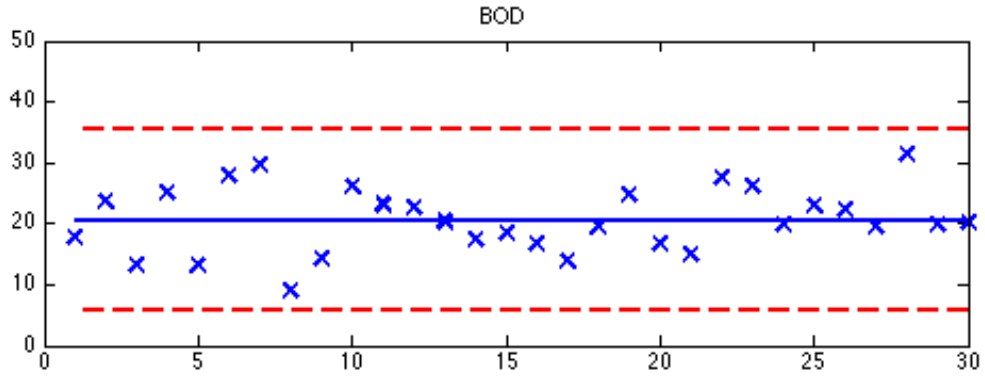
```
    20.3    1392];
```

```
bod.data = data(:,1);
solids.data = data(:,2);
```

Shewhart Charts for BOD

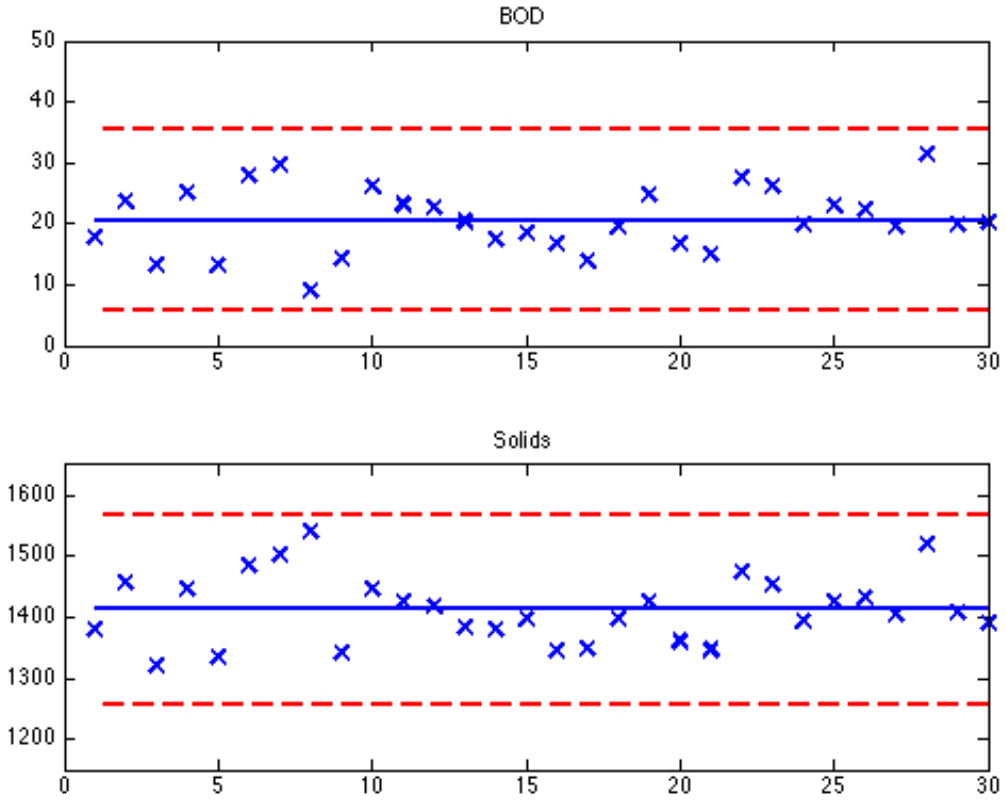
```
bod.mean = mean(bod.data);
bod.std = std(bod.data);
bod.UCL = bod.mean + 2.756*bod.std;
bod.LCL = bod.mean - 2.756*bod.std;
```

```
clf;
subplot(2,1,1);
N = length(bod.data);
plot(1:N,bod.data,'x','Markersize',10,'LineWidth',2);
hold on
plot(1:N,bod.mean*ones(N,1),'-','LineWidth',2);
plot(1:N,bod.UCL*ones(N,1),'r--','LineWidth',2);
plot(1:N,bod.LCL*ones(N,1),'r--','LineWidth',2);
axis([0 N 0 50]);
hold off
title('BOD');
```



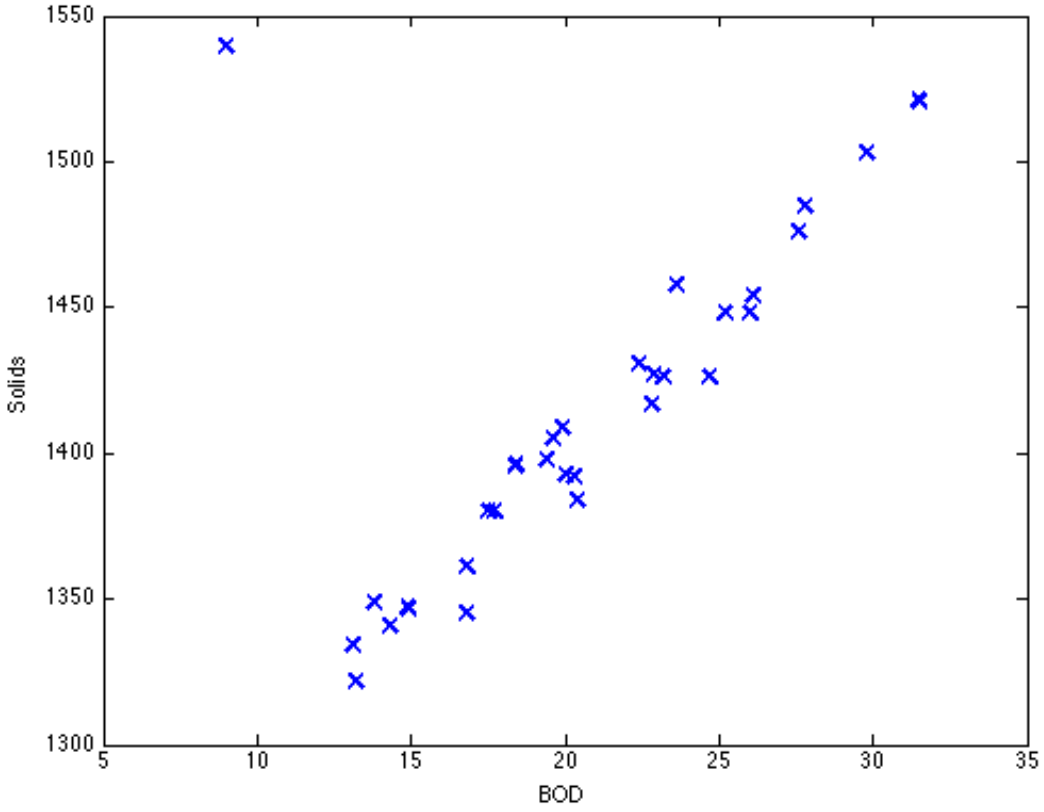

```
solids.mean = mean(solids.data);
solids.std = std(solids.data);
solids.UCL = solids.mean + 2.756*solids.std;
solids.LCL = solids.mean - 2.756*solids.std;
```

```
subplot(2,1,2);
N = length(solids.data);
plot(1:N,solids.data,'x','Markersize',10,'LineWidth',2);
hold on
plot(1:N,solids.mean*ones(N,1),'-','LineWidth',2);
plot(1:N,solids.UCL*ones(N,1),'r--','LineWidth',2);
plot(1:N,solids.LCL*ones(N,1),'r--','LineWidth',2);
axis([0 N 1150 1650]);
hold off
title('Solids');
```



Multivariate Chart

```
figure(2);
plot(bod.data,solids.data,'x','Markersize',10,'LineWidth',2);
xlabel('BOD');
ylabel('Solids');
```



Computing the Covariance Matrix

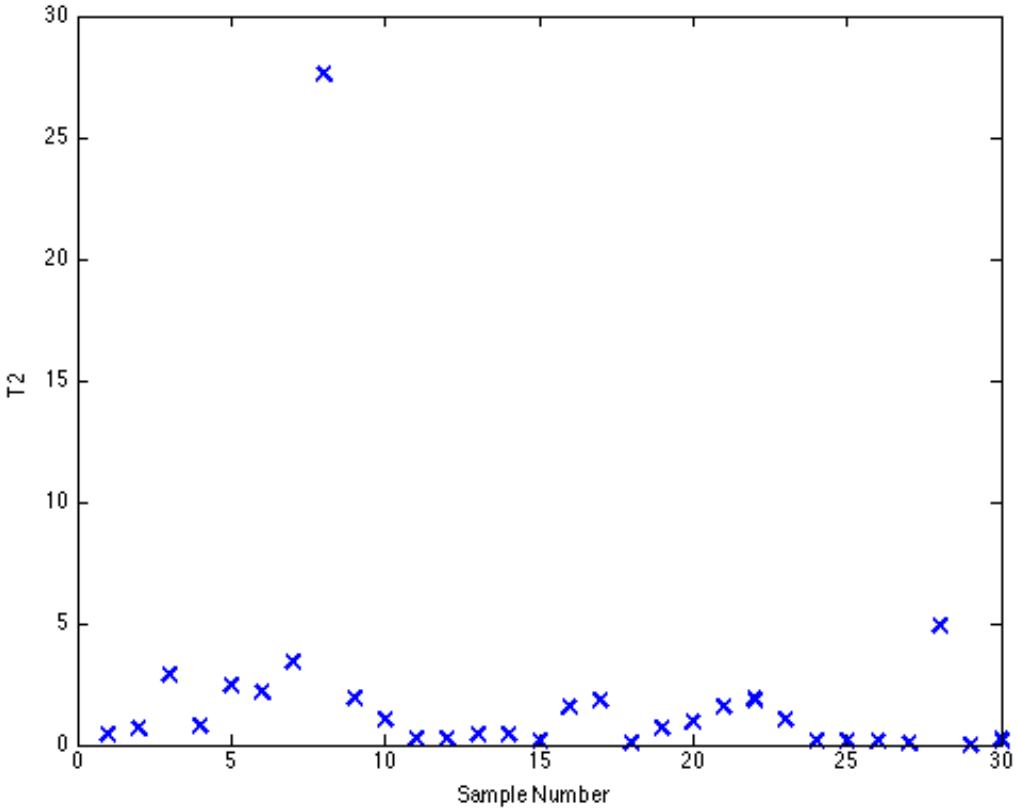
```
N = size(data,1);
I = size(data,2);

X = zeros(N,I);
for i = 1:I
    X(:,i) = data(:,i) - mean(data(:,i));
end

S = (1/N)*X'*X;
```

Hotelling's T

```
X = [data(:,1)-bod.mean, data(:,2)-solids.mean];
N = size(data,1);
for n = 1:N
    T2(n) = X(n,:)*inv(S)*X(n,:)';
end
plot(1:N,T2,'x','Markersize',10,'LineWidth',2);
xlabel('Sample Number');
ylabel('T2');
```



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