PCA of multichannel ECG data

This program illustrates the use of PCA on compressing multichannel ECG data.

Contents

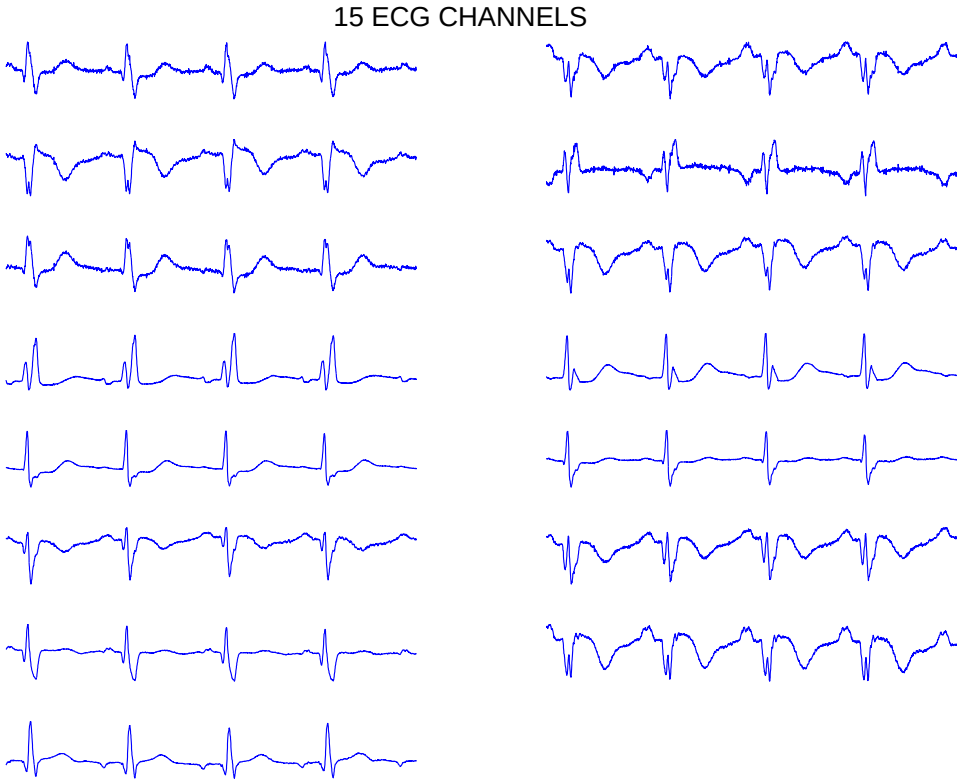
Load data

```
clear
load multichannel_data_1
whos

print_figs_to_file = 0;    % set to 1 or 0
```

```
  Name      Size                    Bytes  Class

  X        15x3000                360000  double array
  t         1x3000                 24000  double array

Grand total is 48000 elements using 384000 bytes
```

Center the data (remove mean from each component)

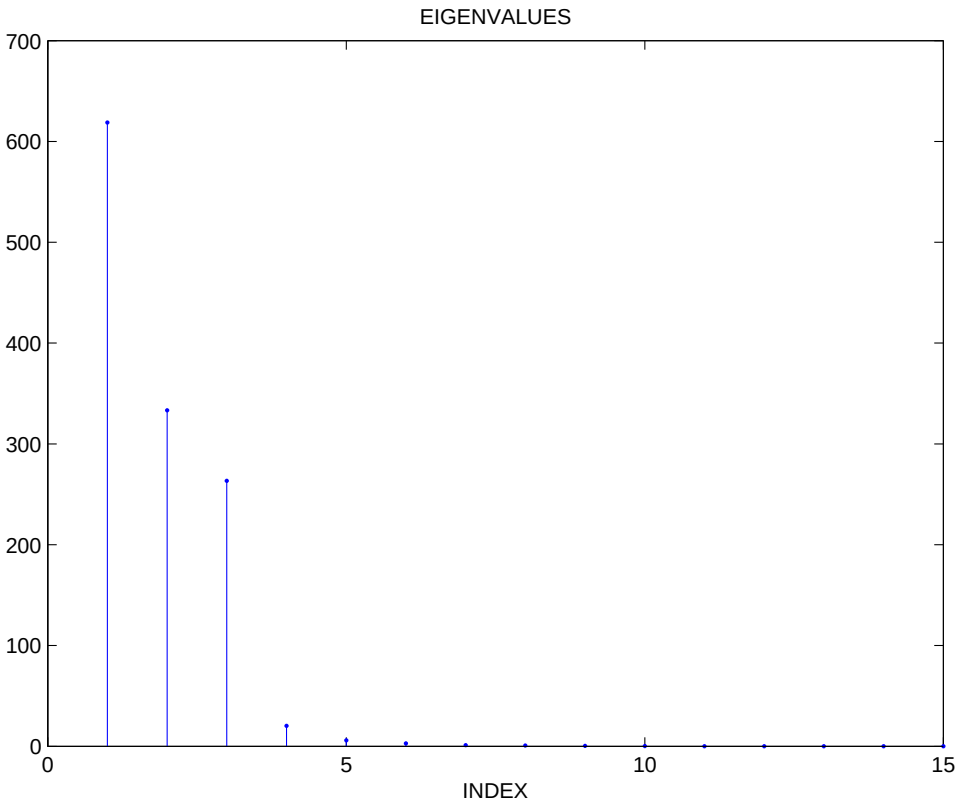
```
for k = 1:15
    X(k,:) = X(k,:) - mean(X(k,:));
end

% display data
clf
suptitle('15 ECG CHANNELS')
for k = 1:15
    subplot(8,2,k)
    plot(t,X(k,:))
    axis tight
    axis off
end
if print_figs_to_file
    orient landscape, print -dpsc pca_ECG_figures
end
```



Compute PCA matrix

```
A = X * X';      % data covariance matrix - 15 x 15 matrix

% compute eigenvectors and eigenvalues
[E,D] = eig(A);

% check that A = E D E'
err = A - E * D * E';
max(abs(err(:)));

% eigevalues in descending order
d = diag(D);
[tmp, k] = sort(-d);

% resort
d = d(k)
D = diag(d);
E = E(:,k);

% check that A = E D E'
err = A - E * D * E';
max(abs(err(:)));

% Set P matrix
P = E';

clf
stem(d,'.')
title('EIGENVALUES')
xlabel('INDEX')
if print_figs_to_file
    orient landscape, print -append -dpsc pca_ECG_figures
end
```

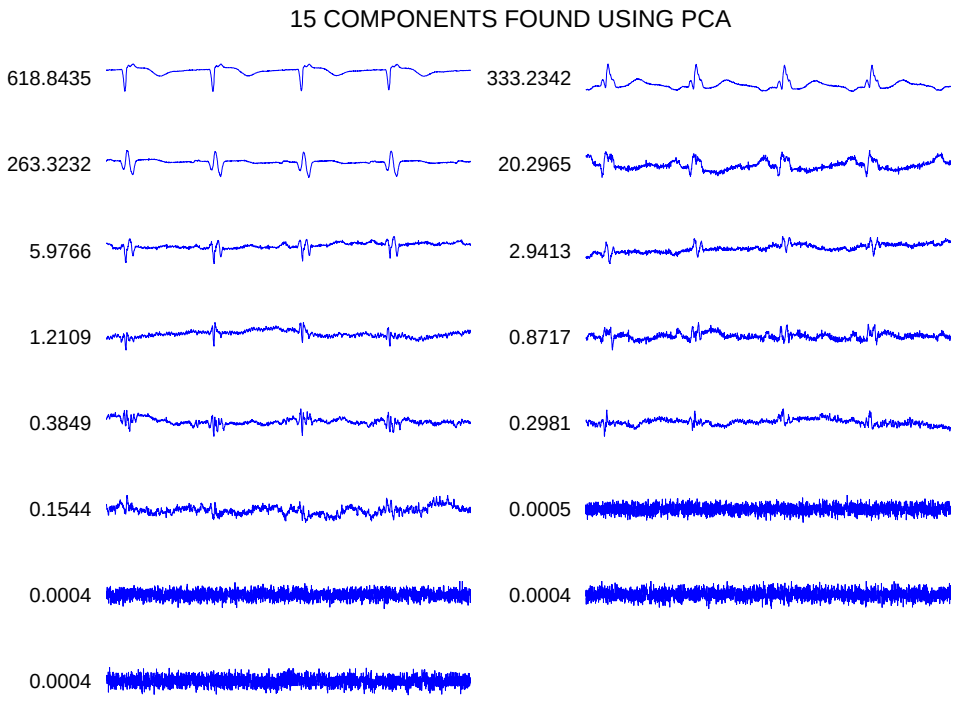
```
d =

  618.8435
  333.2342
  263.3232
   20.2965
    5.9766
    2.9413
    1.2109
    0.8717
    0.3849
    0.2981
    0.1544
    0.0005
    0.0004
    0.0004
    0.0004
```


EIGENVALUES
700
600
500
400
300
200
100
0
0
5
10
15
INDEX

Find components

The components are found using P*X. The eigenvalue of each component is displayed by the plot.

```
% compute the components of the data
Y = P * X;

% display component signals
clf
suptitle('15 COMPONENTS FOUND USING PCA')
for k = 1:15
    subplot(8,2,k)
    plot(t,Y(k,:))
        th = text(t(1)-0.1,0,sprintf('%9.4f',d(k)));
        set(th,'units','normalized');
        set(th,'HorizontalAlignment','right');
    axis tight
    axis off
end
if print_figs_to_file
    orient landscape, print -append -dpsc pca_ECG_figures
end
```



About the eigenvalues...

Note that the eigenvalues are exactly equal to the sum of square of each component.

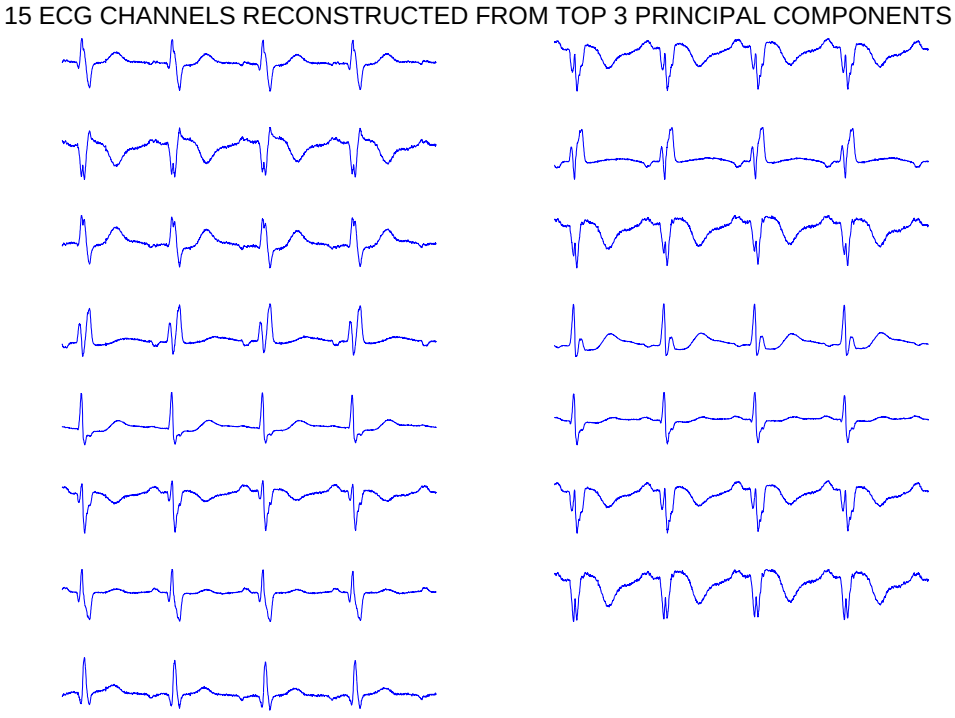
```
S = zeros(15,1);
for k = 1:15
    S(k) = sum(Y(k,:).^2);
end
S

% The values computed here from the principle components
% are exactly the eigenvalue we found earlier.
% You can therefore see that some of the components are very small
% in amplitude.
```

```
S =

  618.8435
  333.2342
  263.3232
   20.2965
    5.9766
    2.9413
    1.2109
    0.8717
    0.3849
    0.2981
    0.1544
    0.0005
    0.0004
    0.0004
    0.0004
```

Approximate all 15 ECG signals using first 3 principle components

If we reconstruct the 15 channels from only the first 3 components, then we obtain a a 15-channel data set that is close to the original 15-channel data set.

```
Y2 = Y;
Y2(4:15,:) = 0;
X_approx = P'*Y2;

% display approximate reconstruction from first 3 principle components
clf
suptitle('15 ECG CHANNELS RECONSTRUCTED FROM TOP 3 PRINCIPAL COMPONENTS')
for k = 1:15
    subplot(8,2,k)
    plot(t,X_approx(k,:))
    axis tight
    axis off
end
if print_figs_to_file
    orient landscape, print -append -dpsc pca_ECG_figures
end
```



Approximate all 15 ECG signals using first 7 principle components

If we reconstruct the 15 channels from only the first 7 components, then we obtain a 15-channel data set that is almost indistinguishable from the original 15-channel data set. Practially all the information in the 15 channels can be represented using only 7 channels.

```
Y2 = Y;
Y2(8:15,:) = 0;
X_approx = P'*Y2;

% display approximate reconstruction from first 7 principle components
clf
suptitle('15 ECG CHANNELS RECONSTRUCTED FROM TOP 7 PRINCIPAL COMPONENTS')
for k = 1:15
    subplot(8,2,k)
    plot(t,X_approx(k,:))
    axis tight
    axis off
end
if print_figs_to_file
    orient landscape, print -append -dpsc pca_ECG_figures
end
```