

2D Confidence Ellipses

from <http://www.visiondummy.com/2014/04/draw-error-ellipse-representing-covariance-matrix/>

```
clear all;
close all;

% Create some random data
s = [2 2];
x = randn(334,1);
y1 = normrnd(s(1).*x,1);
y2 = normrnd(s(2).*x,1);
data = [y1 y2];

% Calculate the eigenvectors and eigenvalues
covariance = cov(data);
[eigenvec, eigenval] = eig(covariance);

% Get the index of the largest eigenvector
[largest_eigenvec_ind_c, r] = find(eigenval == max(max(eigenval)));
largest_eigenvec = eigenvec(:, largest_eigenvec_ind_c);

% Get the largest eigenvalue
largest_eigenval = max(max(eigenval));

% Get the smallest eigenvector and eigenvalue
if(largest_eigenvec_ind_c == 1)
    smallest_eigenval = max(eigenval(:,2))
    smallest_eigenvec = eigenvec(:,2);
else
    smallest_eigenval = max(eigenval(:,1))
    smallest_eigenvec = eigenvec(1,:);
end

% Calculate the angle between the x-axis and the largest eigenvector
angle = atan2(largest_eigenvec(2), largest_eigenvec(1));

% This angle is between -pi and pi.
% Let's shift it such that the angle is between 0 and 2pi
if(angle < 0)
    angle = angle + 2*pi;
end

% Get the coordinates of the data mean
avg = mean(data);

% Get the 95% confidence interval error ellipse
chisquare_val = 2.4477;
theta_grid = linspace(0,2*pi);
```

```
phi = angle;  
X0=avg(1);  
Y0=avg(2);  
a=chisquare_val*sqrt(largest_eigenval);  
b=chisquare_val*sqrt(smallest_eigenval);  
  
% the ellipse in x and y coordinates  
ellipse_x_r = a*cos( theta_grid );  
ellipse_y_r = b*sin( theta_grid );  
  
%Define a rotation matrix  
R = [ cos(phi) sin(phi); -sin(phi) cos(phi) ];  
  
%let's rotate the ellipse to some angle phi  
r_ellipse = [ellipse_x_r;ellipse_y_r]' * R;  
  
% Draw the error ellipse  
plot(r_ellipse(:,1) + X0,r_ellipse(:,2) + Y0,'-')  
hold on;  
  
% Plot the original data  
plot(data(:,1), data(:,2), '.');  
mindata = min(min(data));  
maxdata = max(max(data));  
Xlim([mindata-3, maxdata+3]);  
Ylim([mindata-3, maxdata+3]);  
hold on;  
  
% Plot the eigenvectors  
quiver(X0, Y0, largest_eigenvec(1)*sqrt(largest_eigenval),  
largest_eigenvec(2)*sqrt(largest_eigenval), '-m', 'LineWidth',2);  
quiver(X0, Y0, smallest_eigenvec(1)*sqrt(smallest_eigenval),  
smallest_eigenvec(2)*sqrt(smallest_eigenval), '-g', 'LineWidth',2);  
hold on;  
  
% Set the axis labels  
hXLabel = xlabel('x');  
hYLabel = ylabel('y');
```

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