SIO221A Homework #1 (Eric Gallimore)

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function hw1()

%1. Use MATLAB to generate a series of 2000 random numbers, uniformly distributed

% Make the psuedorandom number generator slightly more random (seed using
% current time so that we get different sets of numbers if we run this
% script more than once)
% If we wanted this to be reproducible, we would use rng('default');
% instead.
rng('shuffle');

x = 10.0 * rand(2000,1);

%Assume that the numbers represent the areas of a random set of disks, with units
%2. Plot
%   -the probability density function and cdf of x
%   -the pdf of y=x^(1/2)
% -the cdf of y=x^(1/2)


% Do x
[x_hist, x_cum, x_bins, x_interval] = custom_hist(x, 20);

figure(1);
clf();

subplot(2,2,1);
plot((x_bins - (x_interval / 2)), x_hist);
%bar((x_bins - (x_interval / 2)), x_hist, 1);
title('PDF of x');
ylabel('Probability density (1/m^2)');
xlabel('Area (m^2)');

subplot(2,2,2);
plot(x_bins, x_cum);
title('Cumulative distribution of x');
ylabel('Probability');
xlabel('Area (m^2)');

% Do y = x / 2
y = sqrt(x);
[y_hist, y_cum, y_bins, y_interval] = custom_hist(y, 20);

subplot(2,2,3);
plot((y_bins - (y_interval / 2)), y_hist);
%bar((y_bins - (y_interval / 2)), y_hist, 1);
title('PDF of y');
ylabel('Probability density (1/m)');
xlabel('Length (m)');
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subplot(2,2,4);
plot(y_bins, y_cum);
title('Cumulative distribution of y');
ylabel('Probability');
xlabel('Lenth (m)');


% 3. Derive the analytic expression for the pdf of y.  Compare with #2 by overplot

% Py(y) = Px(invfunc(y)) * abs(d(invfunc(y)/dy)
% Px is 1/10 (a constant with no x dependence, assuming x is in range
% y = sqrt(x)
% invfunc(y) = x = y^2
% d(invfunc(y))/dy = 2y
% Py(y) = (1/10) * abs(2y)
% Py(y) = abs(y/5)
% absolute value doesn't matter for the range of y > 0, and we care only
% about 0 < y < sqrt(10)
% so, Py(y) = y/5

% Now, plot it over the interval 0 < y < sqrt(10)

y_range = [0:0.01:sqrt(10)];
pdf_y = y_range/5;

% Plot it on top of the numerical PDF of y
subplot(2,2,3);
hold on;
plot(y_range, pdf_y, 'r--');
legend('Numerical', 'Analytical', 'Location', 'NorthWest');


%suptitle({'SIO221A Homework #1: Uniform distribution', 'Eric Gallimore'})
suplabel('Uniform Distribution', 't');




% 4.-6. Repeat for a normally distributed random variable, centered at x=0 with va
%   x= randn(2000,1);
%   y= |x|^(1/2)
%     Please return the requested plots with all axes labeled and all units stated

% randn returns a normal distribution with standard deviation 1 and mean 0
% So, we need to multiply by the standard deviation to get the correct
% distribution.  We know that the variance is 10, so the stddev must be
% sqrt(10).
x = sqrt(10) * randn(2000,1);
[x_hist, x_cum, x_bins, x_interval] = custom_hist(x, 20);
% Do y = x^(1/2)
y = sqrt(abs(x));
[y_hist, y_cum, y_bins, y_interval] = custom_hist(y, 20);
```

```
figure(2);
clf();


subplot(2,2,1);
plot((x_bins - (x_interval / 2)), x_hist);
%bar((x_bins - (x_interval / 2)), x_hist, 1);
title('PDF of x');
ylabel('Probability density (1/m^2)');
xlabel('Area (m^2)');

subplot(2,2,2);
plot(x_bins, x_cum);
title('Cumulative distribution of x');
ylabel('Probability');
xlabel('Area (m^2)');

subplot(2,2,3);
plot((y_bins - (y_interval / 2)), y_hist);
%bar((y_bins - (y_interval / 2)), y_hist, 1);
title('PDF of y');
ylabel('Probability density (1/m)');
xlabel('Length (m)');

subplot(2,2,4);
plot(y_bins, y_cum);
title('Cumulative distribution of y');
ylabel('Probability');
xlabel('Length (m)');

% Py(y) = Px(invfunc(y)) * abs(d(invfunc(y)/dy)
% Px is 1/sqrt(2*pi*sigma^2) * exp(-(x^2/2*sigma^2))
% y = sqrt(abs(x))
% invfunc(y) = x = y^2
% d(invfunc(y))/dy = 2y
% We have to handle each "side" separately because it isn't monotonic, so
% we can't naively use the absolute value of d/dy here.  Instead, we have
% to sum both d/dy's.
% Py(y) = 1/sqrt(2*pi*sigma^2) * exp(-(y^4/2*sigma^2)) * abs(2y + 2y)
% Py(y) = 1/sqrt(20*pi) * exp(-y^4/20) * (4y)



% Now, plot it over the interval 0 < y < sqrt(10)

y = [0:0.01:sqrt(10)];
pdf_y = (1/sqrt(20*pi)) * exp(-(y.^4)/20) .* (4*y);

% Plot it on top of the numerical PDF of y
subplot(2,2,3);
hold on;
plot(y_range, pdf_y, 'r--');
legend('Numerical', 'Analytical', 'Location', 'NorthEast');
```

```
%suptitle({'SIO221A Homework #1: Normal distribution', 'Eric Gallimore'})
suplabel('Normal Distribution', 't');

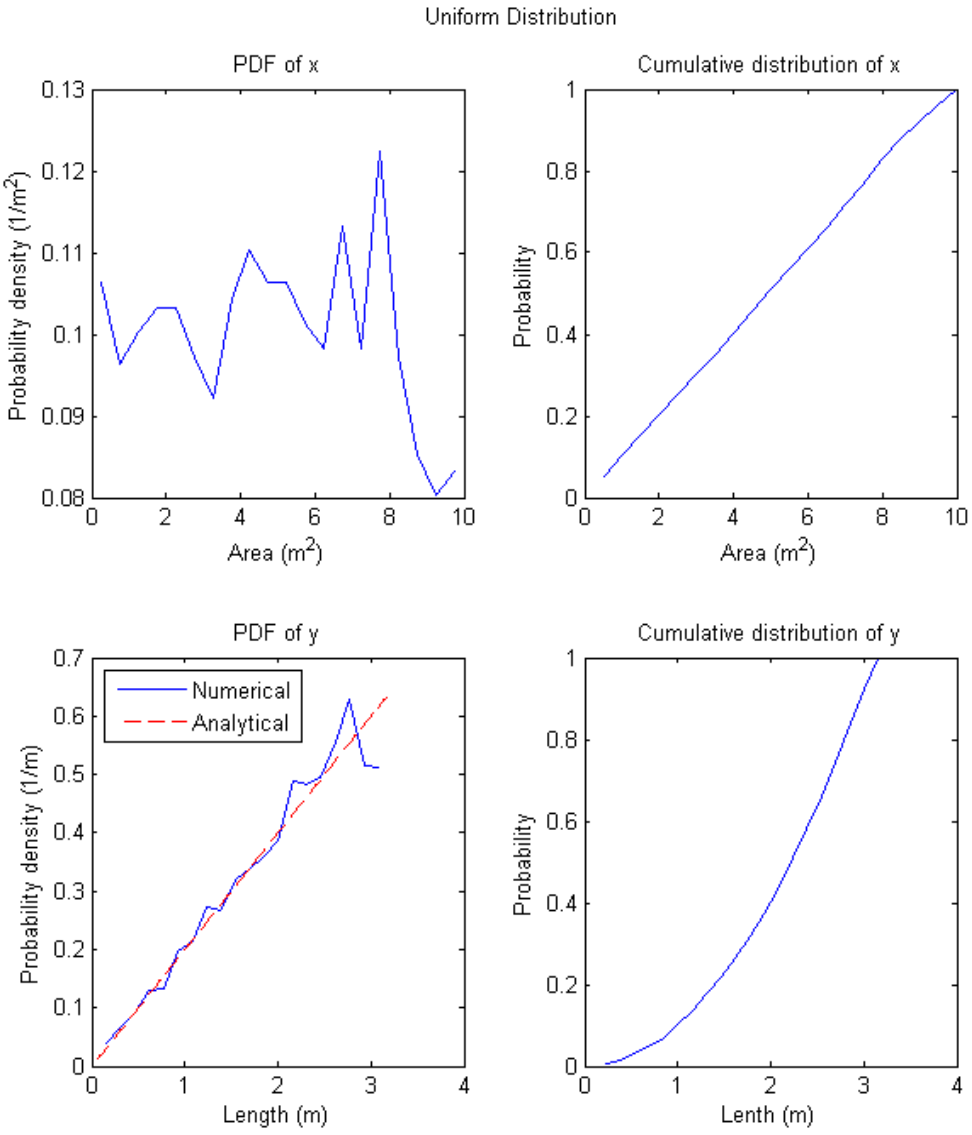

end

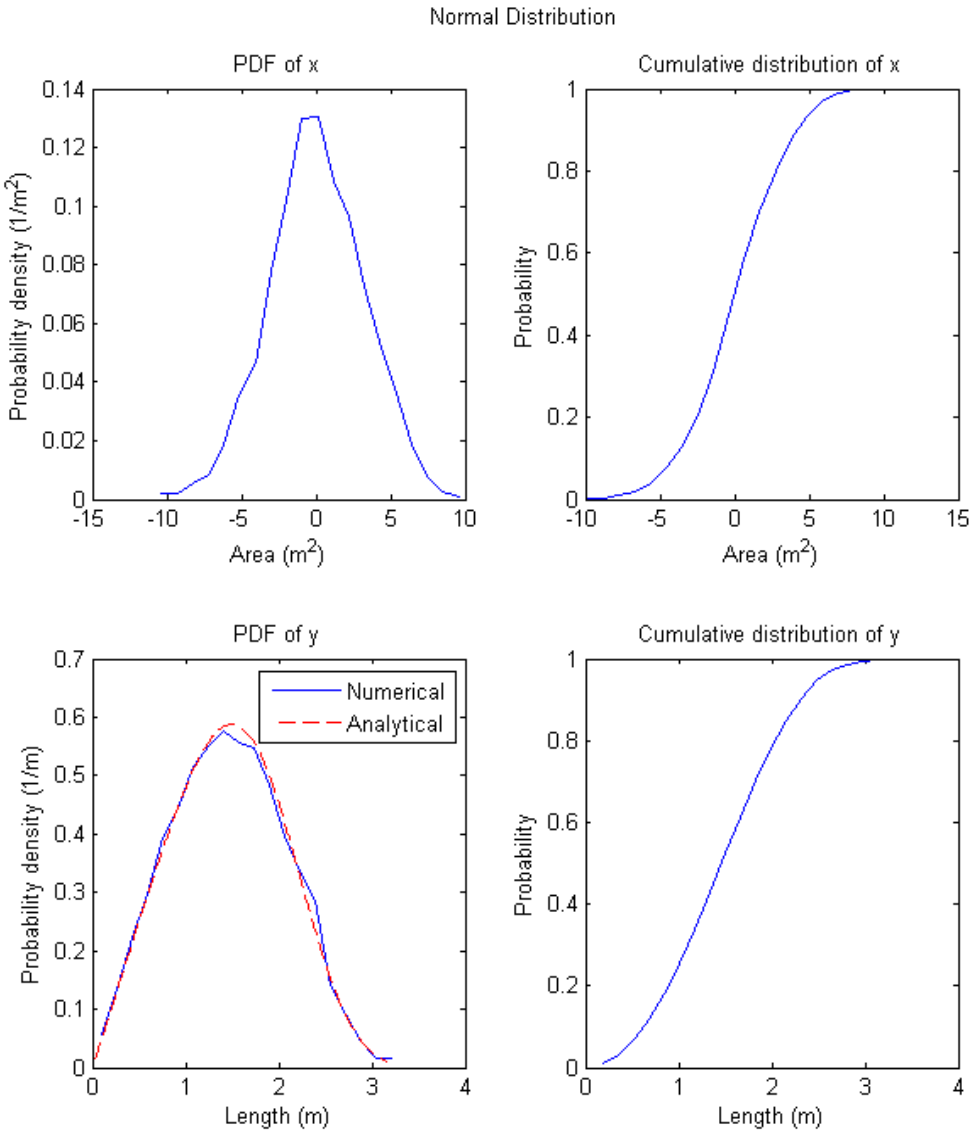
function [pdf_values, cdf_values, bins, interval] = custom_hist(data, num_bins)
% This is a freestanding implemenation of a histogram function
    min_value = min(data);
    max_value = max(data);
    interval = (max_value - min_value) / num_bins;

    bins = (min_value + interval):interval:max_value;

    x_work = data;
    cumulative = 0;
    in_bin = zeros(1,length(bins));
    below_bin = zeros(1,length(bins));
    for i = (1:1:length(bins))
        in_bin(i) = length(x_work(x_work <= bins(i)));
        cumulative = cumulative + in_bin(i);
        below_bin(i) = cumulative;
        x_work = x_work(x_work > bins(i));
    end

    pdf_values = in_bin / length(data) / interval;
    cdf_values = below_bin / length(data);
end
```


Uniform Distribution
PDF of x
Probability density (1/m2)
Area (m2)
Cumulative distribution of x
Probability
Area (m2)
PDF of y
Numerical
Analytical
Probability density (1/m)
Length (m)
Cumulative distribution of y
Probability
Lenth (m)



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