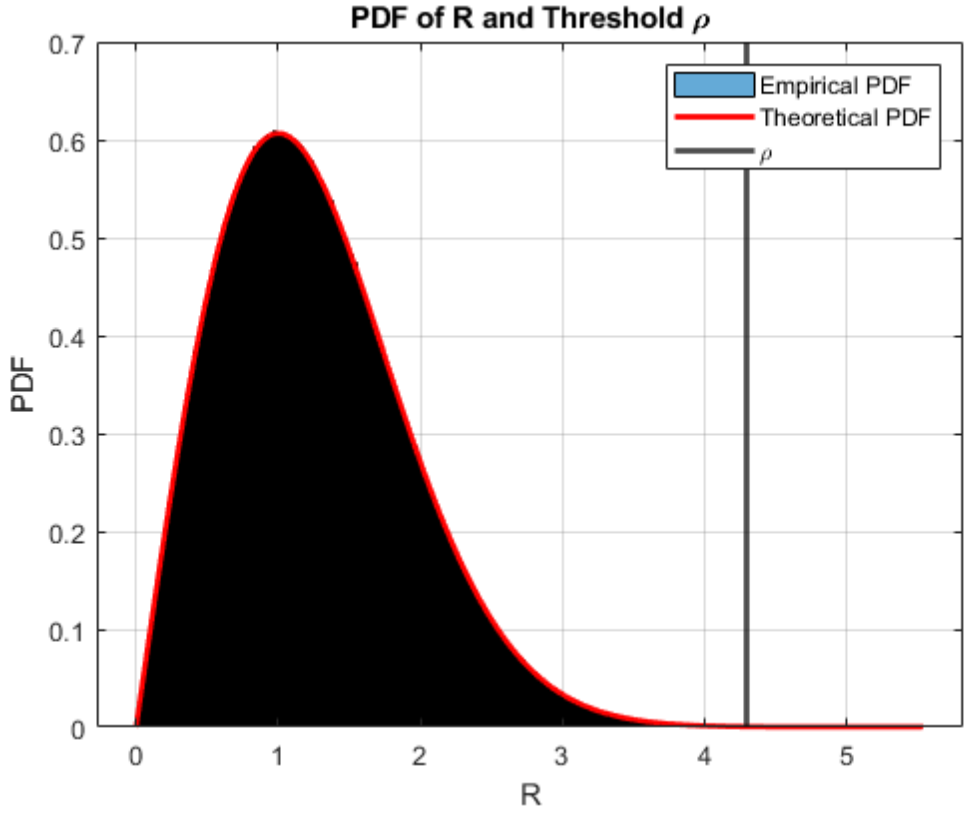
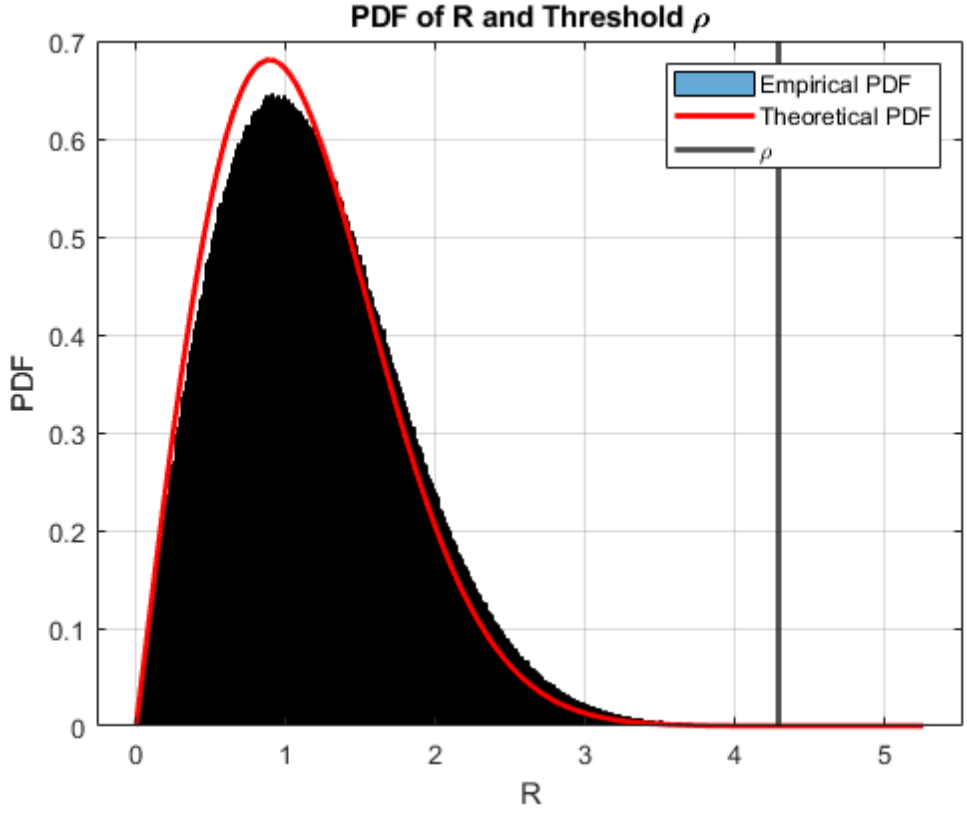
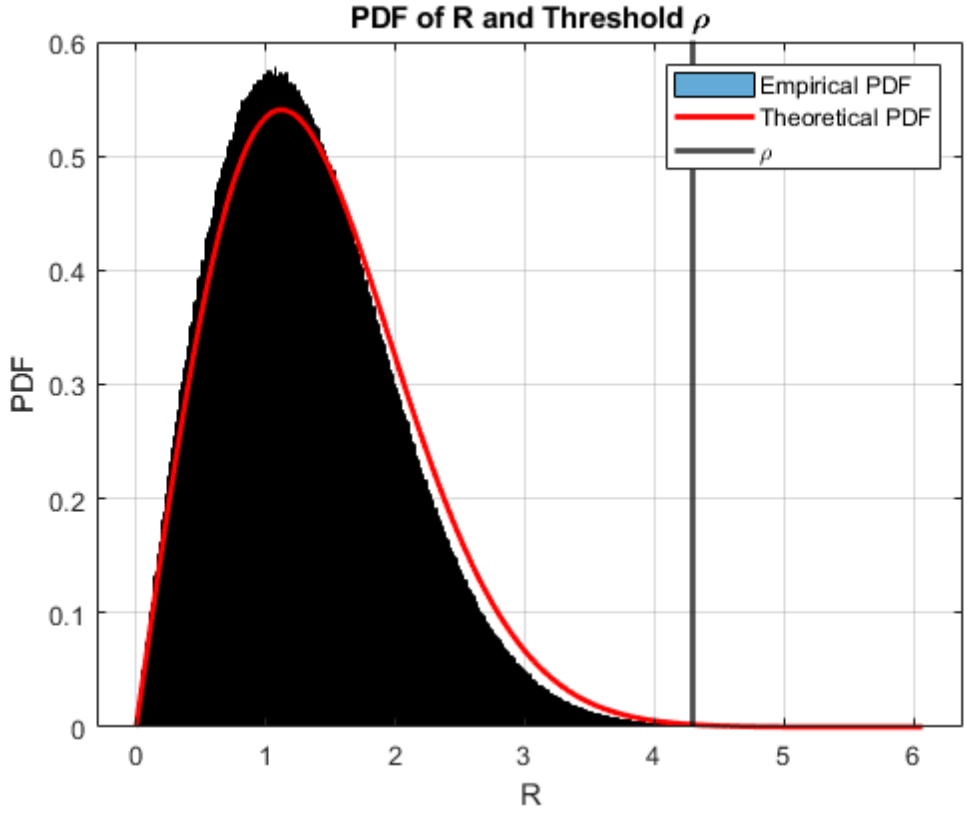
```
clc; clear; close all;

% (a) Compute P(R > rho)
function P_R_greater_rho = P_R_greater_rho_(rho, sigma2)
    % Compute the probability P(R > rho)
    P_R_greater_rho = exp(-rho^2 / (2 * sigma2));
end

% (b) Find rho/sigma so that P(R > rho) = 10^-4
function rho_sigma_ratio = rho_sigma_ratio_(rho_threshold)
    % Find rho/sigma so that P(R > rho) = 10^-4
    rho_sigma_ratio = sqrt(-2 * log(rho_threshold));
end

rho_threshold = 10^-4;
rho_sigma_ratio = rho_sigma_ratio_(10^-4);
fprintf('rho/sigma ratio: %.5f\n', rho_sigma_ratio);

% (c) Sketch R = |n_I + jn_Q|
function R = generateNoise(num_samples, sigma2)
    % Generate noise components
    n_I = randn(num_samples, 1) * sqrt(sigma2);
    n_Q = randn(num_samples, 1) * sqrt(sigma2);
    % Compute the magnitude R
    R = abs(n_I + 1j * n_Q);
end

function plot_pdf(R, rho, sigma2, num_samples)
    % Plot the empirical PDF
    figure;
    histogram(R, 'Normalization', 'pdf');
    hold on;

    % Compute theoretical PDF
    r_vals = linspace(0, max(R), num_samples);
    pdf_vals = (r_vals / sigma2) .* exp(-r_vals.^2 / (2 * sigma2));
    plot(r_vals, pdf_vals, 'r-', 'LineWidth', 2);

    % Add a vertical line at rho
    xline(rho, 'k', 'LineWidth', 2);

    title('PDF of R and Threshold \rho');
    xlabel('R');
    ylabel('PDF');
    legend('Empirical PDF', 'Theoretical PDF', '\rho');
    grid on;
end

% (d) Fraction of time R > rho
function analysis(sigma2, rho, num_samples)
    R = generateNoise(num_samples, sqrt(sigma2));
    plot_pdf(R, rho, sigma2, num_samples);

    frac_R_greater_rho = mean(R > rho);

    % Display results
```

```
    fprintf('Empirical fraction R > rho: %.5f\n', frac_R_greater_rho);
    fprintf('Theoretical P(R > rho): %.5f\n', P_R_greater_rho_(rho, sigma2));
end

sigma2 = 1;
rho = rho_sigma_ratio * sqrt(sigma2);
num_samples = 1e7;

fprintf('\nFor sigma^2 = 1:');
analysis(sigma2, rho, num_samples);


% (e) Decrease sigma^2 by 1 dB
sigma2_decreased = sigma2 * 10^(-1/10);

fprintf('\nFor decreased sigma^2 by 1 dB:');
analysis(sigma2_decreased, rho, num_samples);

% (f) Increase sigma^2 by 1 dB
sigma2_increased = sigma2 * 10^(1/10); % Increase sigma^2 by 1 dB

fprintf('\nFor increased sigma^2 by 1 dB:');
analysis(sigma2_increased, rho, num_samples);
```

```
rho/sigma ratio: 4.29193

For sigma^2 = 1:Empirical fraction R > rho: 0.00010
Theoretical P(R > rho): 0.00010

For decreased sigma^2 by 1 dB:Empirical fraction R > rho: 0.00003
Theoretical P(R > rho): 0.00001

For increased sigma^2 by 1 dB:Empirical fraction R > rho: 0.00026
Theoretical P(R > rho): 0.00066
```


PDF of R and Threshold ρ
Empirical PDF
Theoretical PDF
ρ
PDF
R
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
1
2
3
4
5


PDF of R and Threshold ρ
Empirical PDF
Theoretical PDF
ρ
PDF
R
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
1
2
3
4
5



Published with MATLAB® R2024a