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% Computer Lab 7
% Exercise 2
% EM scheme for the Heston Model
% Pricing a European Call option
h = 0.001;
M = 10000; % number of simulations/paths per value of h
mu = 0.06; % = r
K = 105;
T = 1;
X_0 = 100;
V_0 = 0.2;
rho = 0.5;
xi = 1;
kappa = 5;
theta = 0.15;
N = round(T./h); % number of grid points per simulation
payoffs = zeros(M,1); % for MC estimator
for jj = 1:M
    X = zeros(N,1); % vector to store the path
    dB = sqrt(h).*randn(N,1); % Brownian increments
    dZ = sqrt(h).*randn(N,1);
    X(1,1) = X_0;
    V = zeros(N,1); % vector to store the path
    dV = rho*dB + sqrt(1-rho^2)*dZ; %correlated Brownian increments
    V(1,1) = V_0;
    % simulate the path of X using the EM scheme
    for n = 1:N-1
        V(n+1,1) = V(n,1) + h*kappa*(theta-V(n,1)) ...
            + xi*sqrt(abs(V(n,1)))*dV(n+1,1);
        X(n+1,1) = X(n,1) + h*mu*X(n,1) ...
            + sqrt(abs(V(n,1)))*X(n,1)*dB(n+1,1);
    end
    payoffs(jj,1) = exp(-mu*T)*max(X(N,1)-K,0);
end
% parts (a) and (b)
% Comparing simulated price to the closed form solution (see page 59
 of the
% notes for details)
simulated_prices = mean(payoffs)
%true_price = BS_price(X_0,mu,sigma,T,K)

% part (c)
% Using CLT approximation to produce 95% confidence interval for the
% computed prices
% NB the true price will fall within the computed confidence interval
%approximately 95% of the time - this is testable....
mu_hat = simulated_prices;
sigma_hat = sqrt(var(payoffs));
lower = mu_hat - 1.96*sigma_hat/sqrt(M)
upper = mu_hat + 1.96*sigma_hat/sqrt(M)
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simulated_prices =

  15.857291470333214

lower =

  15.186469796580660

upper =

  16.528113144085768
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