MEMO Number CMPE320_S21_PROJ3_CODE
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1 MATLAB CODE

1.1 Sum of Independent, Identically Distributed (iid) Random Variables from U(0,1)

```
function part2_1()
    figure(1)
    X = rand(2,100000);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(std1);
    grid on;
    hold on;
    disp('Experimental Variance, Mean and Standard Deviation for N = 2:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    r = [-1:0.1:3];
    % Analytical Mean = N*0.5 Analytical Variance = N*1/12
    %N=2
    f_r = (1/(sqrt(2*pi*(1/6)))*(exp(-((r-(2*0.5)).^2)/(2*(1/6)))));
    plot(r,f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from U(0,1) N=2');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(2)
    X = rand(6,100000);
    sum_X = sum(X);
    histogram(sum_X,'Normalization','pdf');
    mean_X = mean(sum_X);
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    disp('Experimental Variance, Mean and Standard Deviation for N = 6:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    r = [-1:0.1:6];
    % Analytical Mean = N*0.5 Analytical Variance = N*1/12
    %N=6
```

```
    f_r = (1/(sqrt(2*pi*(1/2)))*(exp(-((r-3).^2)/(2*(1/2)))));
    plot(r,f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from U(0,1) N=6');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(3)
    X = rand(12,100000);
    sum_X = sum(X);
    histogram(sum_X,'Normalization','pdf');
    mean_X = mean(sum_X);
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    disp('Experimental Variance, Mean and Standard Deviation for N = 12:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n',std(sum_X));
    r = [-1:0.1:12];
    % Analytical Mean = N*0.5 Analytical Variance = N*1/12
    %N=12
    f_r = (1/(sqrt(2*pi*(1)))*(exp(-((r-6).^2)/(2*(1)))));
    plot(r,f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from U(0,1) N=12');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
end
```

1.2 Sum of Independent, Identically Distributed (iid) Discrete Random Variables

```
function part2_2()
    figure(1)
    X = randi(8,2,100000);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 2:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    % Analytical Mean = N*4.5 Analytical Variance = N*5.25
    %N=2
    f_r = (1./(sqrt(2.*pi.*(10.5))).*(exp(-((r-9).^2)/(2.*(10.5)))));
```

```
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Discrete Variable from U(0,1) N=2');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(2)
    X = randi(8,10,100000);
    %disp(X);
    sum_X = sum(X);
    %disp(sum_X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf', 'BinWidth',1);
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 10:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    % Analytical Mean = N*4.5 Analytical Variance = N*5.25
    %N=10
    f_r = (1./(sqrt(2.*pi.*(52.5))).*(exp(-((r-45).^2)/(2.*(52.5)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Discrete Variable from U(0,1) N=10');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(3)
    X = randi(8,50,100000);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 50:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n',std(sum_X));
    % Analytical Mean = N*4.5 Analytical Variance = N*5.25
    %N=50
    f_r = (1./(sqrt(2.*pi.*(262.5))).*(exp(-((r-225).^2)/(2.*(262.5)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Discrete Variable from U(0,1) N=50');
    legend('Histogram','Gaussian Curve');
```

```
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
end
```

1.3 1.3 Sum of Independent, Identically Distributed (iid) Random Variables from $P_x(x) = 0.5e^{-0.5x}$

```
function part2_3()
    figure(1)
    X = randx(2,100000,0.5);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 2:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    % Analytical Mean = N*2 Analytical Variance = N*4
    %N=2
    f_r = (1./(sqrt(2.*pi.*(8))).*(exp(-((r-4).^2)/(2.*(8)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from p_x(x)=0.5e^{-0.5x} N=2');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(2)
    X = randx(10,100000,0.5);
    %disp(X);
    sum_X = sum(X);
    %disp(sum_X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 10:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    % Analytical Mean = N*2 Analytical Variance = N*4
    %N=10
    f_r = (1./(sqrt(2.*pi.*(40))).*(exp(-((r-20).^2)/(2.*(40)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from p_x(x)=0.5e^{-0.5x} N=10');
```

```
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(3)
    X = randx(100,100000,0.5);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 100:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n',std(sum_X));
    % Analytical Mean = N*2 Analytical Variance = N*4
    %N=100
    f_r = (1./(sqrt(2.*pi.*(400))).*(exp(-((r-200).^2)/(2.*(400)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('PDF for Sum of Random Variable from p_x(x)=0.5e^{-0.5x} N=100');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
end
function rexp = randx(n,k,lambda)
%
%function rexp = randx(n,k,lambda)
% Generates samples of an exponentially distributed random variable with
% parameter lambda.
% Calling parameters
%       n:    number of columns in output array rexp
%       m:    number of rows in output array rexp
%       lambda:  exponential distribution parameter, lambda > 0.
%  Returned parameters
%       rexp  an n x k array containing independent samples from an
%       exponential distribution with pdf f(x) = lambda exp( -lambda*x)
%
% Help comments updated 2/13/2021 EFCL
% Original code EFCL ~1989
%
Z = rand(n,k);  % compute a uniformly distributed random variable

% Now treating the Z value as the CDF of the desired exponential random
variable,
% invert the CDF ( F(x) = 1 - exp(-lambda*x) ) to find the equivalent x
% value.  exp(-lambda x) = 1 - F(x) = 1 - Z
%         -lambda x = log(1 - Z)
%             x = -log(1-Z)/lambda

rexp=zeros(n,k);  % establish the memory
rexp=-log(1-Z)/lambda; % invert the CDF.
```

```
end
```

1.4 1.4 Sum of Independent, Identically Distributed (iid) Bernoulli Trials

```
function part2_4()
    figure(1)
    X = (rand(4,100000)<=0.5);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 4:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    %Analytical Mean = N*0.5 Analytical Variance = N*0.25
    %N=4
    f_r = (1./(sqrt(2.*pi.*(1))).*(exp(-((r-2).^2)/(2.*(1)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('Scaled PDF of Random Bernoulli Expirement N=4');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(2)
    [N,edges] = histcounts(sum_X, 'Normalization','pdf');
    edges = edges(2:end) - (edges(2)-edges(1))/2;

    grid on;

    r = [-1:0.1:6];
    f_r = (1./(sqrt(2.*pi.*(1))).*(exp(-((r-2).^2)/(2.*(1)))));
    plot(edges, N, 'LineWidth', 3);
    hold on;
    plot(r,f_r, 'LineWidth', 3);
    hold off;
    xlabel('r');
    ylabel('f(r)');
    title('Theoretical PDF of Random Bernoulli Experiment N=4');
    legend('Histogram','Gaussian Curve');
    figure(3)
    X = (rand(8,100000)<=0.5);
    %disp(X);
    sum_X = sum(X);
    %disp(sum_X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
```

```
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 8:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n\n',std(sum_X));
    %Analytical Mean = N*0.5 Analytical Variance = N*0.25
    %N=8
    f_r = (1./(sqrt(2.*pi.*(2))).*(exp(-((r-4).^2)/(2.*(2)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('Scaled PDF of Random Bernoulli Expirement N=8');
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(4)
    [N,edges] = histcounts(sum_X, 'Normalization','pdf');
    edges = edges(2:end) - (edges(2)-edges(1))/2;

    grid on;

    r = [-1:0.1:12];
    f_r = (1./(sqrt(2.*pi.*(2))).*(exp(-((r-4).^2)/(2.*(2)))));
    plot(edges, N, 'LineWidth', 3);
    hold on;
    plot(r,f_r, 'LineWidth', 3);
    hold off;
    xlabel('r');
    ylabel('f(r)');
    title('Theoretical PDF of Random Bernoulli Experiment N=8');
    legend('Histogram','Gaussian Curve');
    figure(5)
    X = (rand(1000,100000)<=0.5);
    sum_X = sum(X);
    mean_X = mean(sum_X);
    histogram(sum_X,'Normalization','pdf');
    std1 = std(sum_X);
    %disp(var(s1));
    %disp(std1);
    grid on;
    hold on;
    syms r;
    disp('Experimental Variance, Mean and Standard Deviation for N = 1000:');
    fprintf('Mean: %.3f\n',mean(sum_X));
    fprintf('Variance: %.3f\n',var(sum_X));
    fprintf('Standard Deviation: %.3f\n',std(sum_X));
    %Analytical Mean = N*0.5 Analytical Variance = N*0.25
    %N=1000
    f_r = (1./(sqrt(2.*pi.*(250))).*(exp(-((r-500).^2)/(2.*(250)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('Scaled PDF of Random Bernoulli Expirement N=1000');
```

```
    legend('Histogram','Gaussian Curve');
    %y = (1/sqrt(2*pi*(analyticalVariance))*(exp(-((x-
analyticalMean).^2)/(2*(analyticalVariance)))));
    figure(6)
    [N,edges] = histcounts(sum_X, 'Normalization','pdf');
    edges = edges(2:end) - (edges(2)-edges(1))/2;
    plot(edges, N, 'LineWidth', 3);
    grid on;
    hold on;
    syms r;
    f_r = (1./(sqrt(2.*pi.*(250))).*(exp(-((r-500).^2)/(2.*(250)))));
    fplot(f_r, 'LineWidth', 3);
    xlabel('r');
    ylabel('f(r)');
    title('Theoretical PDF of Random Bernoulli Experiment N=1000');
    legend('Histogram','Gaussian Curve');
end
```