

## GA06: Ebola Outbreak II\_LMa\_011019

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%% ETSMP Ebola Outbreak II
% Udvalgte løsninger
clear all

%% Process 1:
% The number of infected is constant independent of the day
%  $Y(n)=X$ 

%% Creation and plot of realisations
days=10;
patients=10;
propability_success=0.5;
yln=binornd(patients,propability_success,1,3) %Three realizations of binomial
random variables;
figure(1);
for i=1:3
    ax=subplot(3,1,i); %Plot of three realizations
    x=linspace(0,10,11);
    plot(ax,x,yln(i),'kx')
    axis([0,10,0,10])
    title(ax,['Realization ',num2str(i)])
    xlabel(ax,'Day')
    ylabel(ax,'#Infected')
end

%% Ensemble mean, brugt side 48 i formelsamling
% For binomial:  $E[x]=n*p$ 
Ensemble_mean1=patients*propability_success % = 5, s 48 i formelsamling

%% Ensemble variance, brugt side 48 i formelsamling
%  $\text{var}(x) = p*n(1-p)$ 
Ensemble_variancel=patients*propability_success*(1-propability_success) % = 2.5

%% Mean and variance of one realization
Realization_mean1=mean(yln(1))
Realization_variancel=var(yln(1))

%% Verifikation med matlab
yln_sim=binornd(patients,propability_success,1,100000);
Ensemble_mean_sim1=mean(yln_sim) %Should be equal to the ensemble mean
Ensemble_var_sim1=var(yln_sim) % Should be equal to the ensemble variance

%% WSS or ergodic?
%% The process is WSS as the mean and variance is constant with time.
%% The process is not ergodic, as one realization has a variance of 0.

%% Process 2
% Stochastic proces:  $Y(n)=X+W(n)$ 
upper=2;
lower=-2;
figure(2);
for i=4:6 %Three realizations
    x=binornd(patients,propability_success,1) %number of infected day 0
    wn=randi([lower upper],1,days+1) %creates discrete uniformly distributed data
    wn(1)=0;
    y2n=x+wn %number of infected day n
    ax=subplot(3,1,i-3); %Plot of three realizations
    x=linspace(0,10,11);
    plot(ax,x,y2n,'kx')
    axis([0,10,0,10])
    title(ax,['Realization ',num2str(i)])
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xlabel(ax, 'Day')
ylabel(ax, '#Infected')
end

%% The ensemble mean and variance?
% Da  $E[y_n] = E[x + w_n] = E[x] + E[w_n]$  og  $E[w_n] = (a+b)/2 = (2+(-2))/2$ ,  $E[x] = n \cdot p$ 
Ensemble_mean2 = (upper + lower) / 2 + patients * propability_success % = 5

% Da  $Var(y_n) = Var(x) + Var(w_n)$  og  $Var(w_n) = ((b-a+1)^2 - 1) / 12$ ,  $Var(w_n) = p \cdot n \cdot (1-p)$ 
Ensemble_variance2 = ((upper - lower + 1)^2 - 1) / 12 + patients * propability_success * (1 - propability_success) % = 4,5

%% Mean and variance of one realization
Realization_mean2 = mean(y2n)
Realization_var2 = var(y2n)

%% Verifikation med Matlab funktion, vi bør gøre dette for alle 10 dage, men da
processen er WSS kan vi nøjes med dag 1
testDag1 = binornd(patients, propability_success, 1, 10000) + randi([-2 2], 1, 10000);
Ensemble_mean_sim2 = mean(testDag1) % skal gerne give 5
Ensemble_var_sim2 = var(testDag1) % skal gerne give 4.5

%% WSS or ergodic?
%% The process is WSS as the mean and variance is constant with time.
%% The process is not ergodic, as the timely mean is not always equal to the
ensemble mean.

%% Process 3:
% Giving the population symptoms and infection
Population = rand(1, 1000); % Number of population

for n = 1:length(Population)
if Population(n) <= 0.2 % Infected and symptoms
    Infected(n) = 1;
    Symptoms(n) = 1;
elseif 0.2 < Population(n) && Population(n) <= 0.5 % Symptoms but not infected
    Infected(n) = 0;
    Symptoms(n) = 1;
elseif Population(n) > 0.99 % Infected and no symptoms
    Infected(n) = 1;
    Symptoms(n) = 0;
else % No symptoms and not infected
    Infected(n) = 0;
    Symptoms(n) = 0;
end
end

%% Realizations of an outbreak in hospital
N_tot_realizations = 3;
for N_realization = 1:N_tot_realizations
    N = randi(length(Population), 1, 10); % Ten random selected persons from the
population
    N_Infected(1:days) = 0;
    for k = 1:10
        N_Infected(1) = N_Infected(1) + Infected(N(k)); % The infected people of the
selection
    end

    for day = 2:days
        N_Infected(day) = N_Infected(day-1);
        for n = 1:N_Infected(day-1)
            Infected_new = randi(2) - 1; % Every infected patient infects 0 or 1 new
person pr. day
            N_Infected(day) = N_Infected(day) + Infected_new; % The total number of
infected on day "day"
        end
    end
end

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        end
    end
    Realization=N_realization
    Number_infected_day=N_Infected
end

%% WSS or ergodic?
%% The process is not WSS as the mean is increasing in time (days).
%% The process is not ergodic, as it is not WSS.
```

## >> ETSMP\_Ebola II\_solution\_LMa\_011019

### Process 1:

$y_{1n} = 7 \quad 6 \quad 3$

Ensemble\_mean1 = 5

Ensemble\_variance1 = 2.5000

Realization\_mean1 = 7

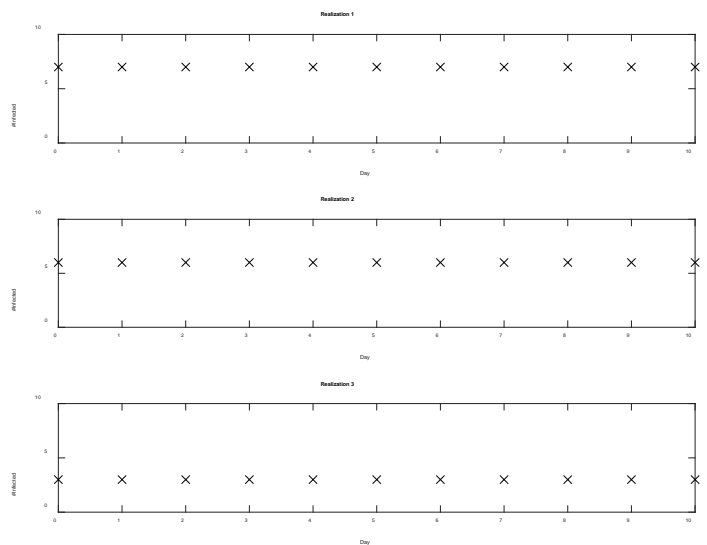
Realization\_variance1 = 0

Ensemble\_mean\_sim1 = 4.9980

Ensemble\_var\_sim1 = 2.4937

The process is WSS as the mean and variance is constant with time.

The process is not ergodic, as one realization has a variance of 0.



### Process 2:

Realization 1:

$x = 3$

$w_n = -1 \quad 1 \quad -2 \quad 1 \quad 1 \quad -1 \quad 2 \quad -2 \quad 0 \quad -1 \quad -1$

$y_{2n} = 3 \quad 4 \quad 1 \quad 4 \quad 4 \quad 2 \quad 5 \quad 1 \quad 3 \quad 2 \quad 2$

Realization 2:

$x = 6$

$w_n = 1 \quad 0 \quad 0 \quad 2 \quad 0 \quad 2 \quad -1 \quad 1 \quad -1 \quad -2 \quad -2$

$y_{2n} = 6 \quad 6 \quad 6 \quad 8 \quad 6 \quad 8 \quad 5 \quad 7 \quad 5 \quad 4 \quad 4$

Realization 3:

$x = 7$

$w_n = 0 \quad 1 \quad -2 \quad 1 \quad 2 \quad 1 \quad 1 \quad -1 \quad 0 \quad 1 \quad 2$

$y_{2n} = 7 \quad 8 \quad 5 \quad 8 \quad 9 \quad 8 \quad 8 \quad 6 \quad 7 \quad 8 \quad 9$

Ensemble\_mean2 = 5

Ensemble\_variance2 = 4.5000

Realization\_mean2 = 7.5455

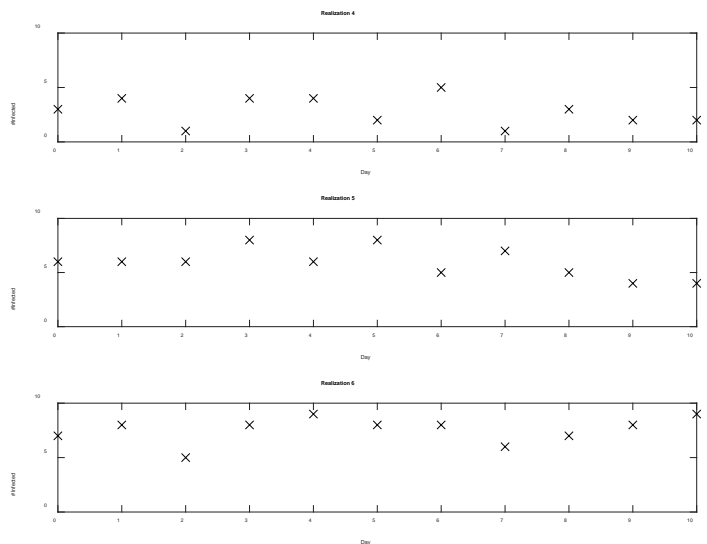
Realization\_var2 = 1.4727

Ensemble\_mean\_sim2 = 5.0048

Ensemble\_var\_sim2 = 4.6226

The process is WSS as the mean and variance is constant with time.

The process is not ergodic, as the timely mean is not always equal to the ensemble mean.



### Process 3:

Realization = 1

Number\_infected\_day = 3   5   9   16   25   41   62   92   140   209

Realization = 2

Number\_infected\_day = 0   0   0   0   0   0   0   0   0   0

Realization = 3

Number\_infected\_day = 2   3   3   5   5   8   12   16   23   32

The process is not WSS as the ensemble-mean is increasing in time (days).

The process is not ergodic, as it is not WSS.