% This is the Maltlab code for simulations in Figure 3 of manuscript MBE-3043

clear

clc

T=50; N=50\*2^8; dt=T/N;

R=4; Dt=R\*dt\*10; L=N/R;

n1=randn(1,L);

n2=randn(1,L);

n3=randn(1,L);

n4=randn(1,L);

% initial value

Szero=5000; I1zero=0.4;I2zero=20; Rzero=10;

% values of the parameters

Lambda=250; beta11=0.0168; beta12=0.009; b1=0.5; alpha1=10;

beta21=0.0042; beta22=0.002; b2=0.02; alpha2=10; mu0=0.6; v=0.4;

r=0.2;r1=0.3;r2=0.2;mu1=0.65;

sigma1=0.08;sigma2=0.05;sigma3=0.05;sigma4=0.02;

S1temp=Szero; I101temp=I1zero; I201temp=I2zero; R1temp=Rzero;

for j=1:L

S1temp=S1temp+(Lambda-(beta11-beta12\*I101temp/(b1+I101temp))\*S1temp\*I101temp/(1+alpha1\*I101temp)-(beta21-beta22\*I201temp/(b2+I201temp))\*S1temp\*I201temp/(1+alpha2\*I201temp)-(mu0+v)\*S1temp)\*Dt+S1temp\*sigma1\*sqrt(Dt)\*n1(j)+sigma1\*sigma1\*S1temp\*(n1(j)\*n1(j)-1)\*Dt/2;

I101temp=I101temp+((beta11-beta12\*I101temp/(b1+I101temp))\*S1temp\*I101temp/(1+alpha1\*I101temp)+(beta21-beta22\*I201temp/(b2+I201temp))\*S1temp\*I201temp/(1+alpha2\*I201temp)-(mu0+r+r1)\*I101temp)\*Dt+I101temp\*sigma2\*sqrt(Dt)\*n2(j)+sigma2\*sigma2\*I101temp\*(n2(j)\*n2(j)-1)\*Dt/2;

I201temp=I201temp+(r\*I101temp-(mu0+mu1+r2)\*I201temp)\*Dt+I201temp\*sigma3\*sqrt(Dt)\*n3(j)+sigma3\*sigma3\*I201temp\*(n3(j)\*n3(j)-1)\*Dt/2;

R1temp=R1temp+(r1\*I101temp+r2\*I201temp+v\*S1temp-mu0\*R1temp)\*Dt+R1temp\*sigma4\*sqrt(Dt)\*n4(j)+sigma4\*sigma4\*R1temp\*(n4(j)\*n4(j)-1)\*Dt/2;

S1em(j)=S1temp;

I101em(j)=I101temp;

I201em(j)=I201temp;

R1em(j)=R1temp;

Ratio(j)=I101em(j)/(S1em(j)+I101em(j)+I201em(j)+R1em(j));

end

for k=1:60

ratio(k)=Ratio(5+k);

end

% The incidence rates of hepatitis B in Figure 1(b)

y=[75.13 84.82 89 88.52 88.82 79.46 81.54 80.68 71.12 69.05 68.57 68.74 72.61 71.99 71.77 64.29 69.25]\*10^(-5)

n=length(y);

x=1:2:33;

figure; % fitting with the real data

plot(ratio,'LineWidth',1.5);

hold on;

plot(x,y,'b--\*','LineWidth',1.5,'MarkerSize',5,'MarkerFaceColor','g','MarkerEdgeColor','k')

xlabel('Year', 'Fontname', 'Times New Roman', 'Fontsize', 16);

ylabel('Percentage of acute infection', 'Fontname', 'Times New Roman','Fontsize', 14);

X1=[1 5 9 13 17 21 25 29 33];

set(gca,'xtick',X1)

set(gca, 'xTickLabel', {'2005', '2007', '2009', '2011', '2013', '2015', '2017', '2019','2021'}, 'Fontname', 'Times New Roman', 'Fontsize', 14);

figure; %Long time behavior

plot(Ratio(6:400),'LineWidth',1.5);

hold on;

plot(x,y,'k--\*','LineWidth',1.5,'MarkerSize',5,'MarkerFaceColor','g','MarkerEdgeColor','k')

xlabel('Year', 'Fontname', 'Times New Roman', 'Fontsize', 16);

ylabel('Percentage of acute infection', 'Fontname', 'Times New Roman','Fontsize', 14);

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% This is the Maltlab code for simulations in Figure 4 of manuscript MBE-3043

clear

clc

T=50; N=50\*2^8; dt=T/N;

R=4; Dt=R\*dt\*10; L=N/R;

n1=randn(1,L);

n2=randn(1,L);

n3=randn(1,L);

n4=randn(1,L);

% initial value

Szero=0.9; I1zero=0.4;I2zero=0.2; Rzero=0.1;

% values of the parameters

Lambda=0.1; beta11=0.25; beta12=0.1; b1=0.5; alpha1=5;

beta21=0.2; beta22=0.1; b2=0.02; alpha2=5; mu0=0.5; v=0.4;

r=0.1;r1=0.4;r2=0.3;mu1=0.45;

sigma1=0.2;sigma2=0.8;sigma3=0.9;sigma4=0.1;

S1temp=Szero; I101temp=I1zero; I201temp=I2zero; R1temp=Rzero;

for j=1:L %随机模型

S1temp=S1temp+(Lambda-(beta11-beta12\*I101temp/(b1+I101temp))\*S1temp\*I101temp/(1+alpha1\*I101temp)-(beta21-beta22\*I201temp/(b2+I201temp))\*S1temp\*I201temp/(1+alpha2\*I201temp)-(mu0+v)\*S1temp)\*Dt+S1temp\*sigma1\*sqrt(Dt)\*n1(j)+sigma1\*sigma1\*S1temp\*(n1(j)\*n1(j)-1)\*Dt/2;

I101temp=I101temp+((beta11-beta12\*I101temp/(b1+I101temp))\*S1temp\*I101temp/(1+alpha1\*I101temp)+(beta21-beta22\*I201temp/(b2+I201temp))\*S1temp\*I201temp/(1+alpha2\*I201temp)-(mu0+r+r1)\*I101temp)\*Dt+I101temp\*sigma2\*sqrt(Dt)\*n2(j)+sigma2\*sigma2\*I101temp\*(n2(j)\*n2(j)-1)\*Dt/2;

I201temp=I201temp+(r\*I101temp-(mu0+mu1+r2)\*I201temp)\*Dt+I201temp\*sigma3\*sqrt(Dt)\*n3(j)+sigma3\*sigma3\*I201temp\*(n3(j)\*n3(j)-1)\*Dt/2;

R1temp=R1temp+(r1\*I101temp+r2\*I201temp+v\*S1temp-mu0\*R1temp)\*Dt+R1temp\*sigma4\*sqrt(Dt)\*n4(j)+sigma4\*sigma4\*R1temp\*(n4(j)\*n4(j)-1)\*Dt/2;

S1em(j)=S1temp;

I101em(j)=I101temp;

I201em(j)=I201temp;

R1em(j)=R1temp;

end

figure;

plot(S1em(1:1000),'b','linewidth',1.5);hold on

xlabel({'t','(a)'},'FontSize',20);

ylabel('S(t)','FontSize',20);

set(gca,'FontName','Times New Roman','FontSize',20,'LineWidth',1.5);

figure;

plot(I101em(1:150),'r','linewidth',1.5);hold on

xlabel({'t','(b)'},'FontSize',20);

ylabel('I\_1(t)','FontSize',20);

set(gca,'FontName','Times New Roman','FontSize',20,'LineWidth',1.5);

figure;

plot(I201em(1:150),'m','linewidth',1.5);

xlabel({'t','(c)'},'FontSize',20);

ylabel('I\_2(t)','FontSize',20);

set(gca,'FontName','Times New Roman','FontSize',20,'LineWidth',1.5);

figure;

plot(R1em(1:1000),'g','linewidth',1.5);

xlabel({'t','(d)'},'FontSize',20);

ylabel('R(t)','FontSize',20);

set(gca,'FontName','Times New Roman','FontSize',20,'LineWidth',1.5);