Example: COVID-2019 data for Hubei, China

Table of Contents

I am taking some data from John Hopkins university [1]

[1] https://github.com/CSSEGISandData/COVID-19

Important notice:

The fitting is here more challenging than in Example 1 because the term "Confirmed patient" used in the database does not precise whether they have been quarantined or not. In a previous version of the submision (version <1.5) , the infectious cases were erroneously used instead of the quarantined cases.

Initialisation

The parameters are here taken as constant except the death rate and the cure rate.

```
clearvars;close all;clc;
% Download the data from ref [1] and read them with the function getDataCOVID
[tableConfirmed,tableDeaths,tableRecovered,time] = getDataCOVID();
% time = time(1:end-1);
fprintf(['Most recent update: ',datestr(time(end)),'\n'])
```

```
Most recent update: 13-Apr-2020
```

```


Location = 'Hubei';

try
    indR = find(contains(tableRecovered.ProvinceState,Location)==1);
    indC = find(contains(tableConfirmed.ProvinceState,Location)==1);
    indD = find(contains(tableDeaths.ProvinceState,Location)==1);
catch exception
    searchLoc = strfind(tableRecovered.ProvinceState,Location);
    indR = find(~cellfun(@isempty,searchLoc)) ;

    searchLoc = strfind(tableConfirmed.ProvinceState,Location);
    indC = find(~cellfun(@isempty,searchLoc))  ;

    searchLoc = strfind(tableDeaths.ProvinceState,Location);
    indD = find(~cellfun(@isempty,searchLoc))   ;
end

disp(tableRecovered(indR,1:2))
```

```
    ProvinceState    CountryRegion
    _____________    _____________

       "Hubei"          "China"
```

```
disp(tableConfirmed(indC,1:2))
```

```
    ProvinceState    CountryRegion
    _____________    _____________

       "Hubei"          "China"
```

```
disp(tableDeaths(indD,1:2))
```

```
    ProvinceState    CountryRegion
    _____________    _____________

       "Hubei"          "China"
```

```

indR = indR(1);
indD = indD(1);
indC = indC(1);





Recovered = table2array(tableRecovered(indR,5:end));
Deaths = table2array(tableDeaths(indD,5:end));
Confirmed = table2array(tableConfirmed(indC,5:end));
% If the number of confirmed cases is small, it is difficult to know whether
% the quarantine has been rigorously applied or not. In addition, this
% suggests that the number of infectious is much larger than the number of
% confirmed cases
minNum= round(0.3*max(Confirmed));
Recovered(Confirmed<=minNum)=[];
Deaths(Confirmed<=minNum)=[];
time(Confirmed<=minNum)= [];
Confirmed(Confirmed<=minNum)=[];

if isempty(Confirmed)
    warning('"Confirmed" is an empty array. Check the value of "minNum". Computation ab
    return
end


Npop= 14e6; % population
```

Fitting of the generalized SEIR model to the real data

```
% Definition of the first estimates for the parameters
alpha_guess = 0.06; % protection rate
beta_guess = 0.9; % Infection rate
LT_guess = 5; % latent time in days
Q_guess = 0.1; % rate at which infectious people enter in quarantine
lambda_guess = [0.1,0.05]; % recovery rate
kappa_guess = [0.08,0.03]; % death rate
```

```
guess = [alpha_guess,...
    beta_guess,...
    1/LT_guess,...
    Q_guess,...
    lambda_guess,...
    kappa_guess];


% Initial conditions
E0 = Confirmed(1); % Initial number of exposed cases. Unknown but unlikely to be zero.
I0 = Confirmed(1); % Initial number of infectious cases. Unknown but unlikely to be zer
Q0 = Confirmed(1)-Recovered(1)-Deaths(1);
R0 = Recovered(1);
D0 = Deaths(1);

% Active cases
Active = Confirmed-Recovered-Deaths;
Active(Active<0) = 0; % No negative number possible
% Parameter estimation with the lsqcurvefit function
[alpha1,beta1,gamma1,delta1,Lambda1,Kappa1] = ...
    fit_SEIQRDP(Active,Recovered,Deaths,Npop,E0,I0,time,guess,'Display','off');
```

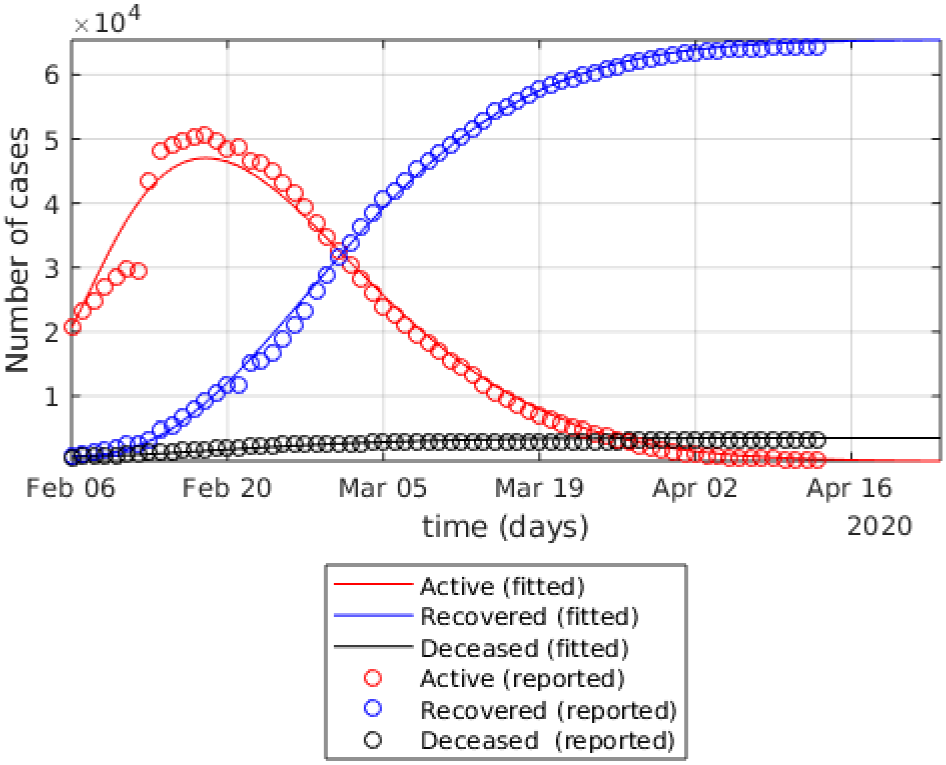
Simulate the epidemy outbreak based on the fitted parameters

```
dt = 1/24; % time step
time1 = datetime(time(1)):dt:datetime(datestr(floor(datenum(now))+datenum(10)));
N = numel(time1);
t = [0:N-1].*dt;
[S,E,I,Q,R,D,P] = SEIQRDP(alpha1,beta1,gamma1,delta1,Lambda1,Kappa1,Npop,E0,I0,Q0,R0,D0
```

Comparison of the fitted and real data

Active cases = Confirmed-Deaths-Recovered (database) = Quarantined (SEIQRDP model)

```
figure
semilogy(time1,Q,'r',time1,R,'b',time1,D,'k');
hold on
semilogy(time,Active,'ro',time,Recovered,'bo',time,Deaths,'ko');
% ylim([0,1.1*Npop])
ylabel('Number of cases')
xlabel('time (days)')
leg = {'Active (fitted)',...
        'Recovered (fitted)','Deceased (fitted)',...
        'Active (reported)','Recovered (reported)','Deceased  (reported)'};
legend(leg{:},'location','southoutside')
set(gcf,'color','w')
grid on
axis tight
set(gca,'yscale','lin')
```


×10^4
6
5
4
3
2
1
Number of cases
Feb 06
Feb 20
Mar 05
Mar 19
Apr 02
Apr 16
2020
time (days)
Active (fitted)
Recovered (fitted)
Deceased (fitted)
Active (reported)
Recovered (reported)
Deceased (reported)