

Research Article

Forecasting Confirmed Cases, Deaths, and Recoveries from COVID-19 in China during the Early Stage

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To provide a theoretical basis for the prevention and control of COVID-19 in China, confirmed cases, deaths, and recoveries from COVID-19 in China were predicted using a fractional grey model. The results indicated that the grey model has high forecasting accuracy in the prediction of disease spread.

1. Introduction

The outbreak of the novel coronavirus disease-2019 (COVID-19) caused by SARS-CoV-2 took place in December 2019 in Wuhan, China. This disease can cause severe fever and, in the worst cases, acute respiratory failure syndrome [1]. There were 1016 recorded deaths from this outbreak as of February 10, 2020, in China. It has also spread across other countries, starting with Japan and then Australia, France, and the United States. The SARS-CoV-2 virus continues to evolve in alarming ways, with the spread of COVID-19, putting enormous strain on health systems around the world. There is no indication that China will succeed in beating COVID-19 in the short term. Accurately forecasting the epidemic tendency can provide a theoretical basis for the prevention and control of COVID-19.

Statistical methods are widely used for forecasting of epidemic diseases [2]. Traditional prediction methods often require a large number of data samples, which follow a certain typical distribution. However, because of the limited information available during the early stages of disease transmission, the spreading mechanism of COVID-19 is yet to be fully understood [3]. The grey prediction theory provides a new way to solve the systemic problems that occur in cases of limited information. Thus, the grey

prediction theory is more suitable for the prediction of the incidence of COVID-19 in China than other theories.

The rest of the paper is arranged as follows. Section 2 introduces the forecasting model. Section 3 shows in detail the prediction results. Conclusions are drawn in Section 4.

2. Fractional Grey Model

Grey system theory mainly focuses on systems with incomplete or uncertain information [4]. In recent years, grey system theory has been successfully applied to the prediction of infectious diseases [5–8].

Despite the widespread outbreak of COVID-19, data on this disease in China are limited. Many methods cannot make accurate predictions if the data samples are small. For this reason, the fractional grey model (FGM(1,1)) is used to deal with the forecasting problem with limited samples [9]. The FGM(1,1) model is an optimized form of the grey prediction model. Its detailed modeling process has been described previously [9, 10].

3. Results

In this section, the data are from the National Health Commission of the People's Republic of China (<http://www.nhc.gov.cn/>). The Chinese government has made every effort

TABLE 1: Prediction of confirmed cases of COVID-19 in China.

Data	Actual values	FGM(1,1)	MAPE
21-Jan	291		
22-Jan	440		
23-Jan	571		
24-Jan	1287		
25-Jan	1975		
26-Jan	2744	3207	16.89
27-Jan	4515	3961	12.27
28-Jan	5974	6462	8.17
29-Jan	7711	8362	8.44
30-Jan	9692	9881	1.95
31-Jan	11,791	12,037	2.08
1-Feb	14,380	14,103	1.92
2-Feb	17,205	17,271	0.38
3-Feb	20,438	20,418	0.10
4-Feb	24,324	23,973	1.44
5-Feb	28,018	28,593	2.05
6-Feb	28,985	31,792	9.68
7-Feb	31,774	30,893	2.77
8-Feb	33,738	33,145	1.76
9-Feb	35,982	35,965	0.05
Mean			4.66

TABLE 2: Prediction of the death toll due to COVID-19.

Data	Actual values	FGM(1,1)	MAPE
22-Jan	9		
23-Jan	17		
24-Jan	41		
25-Jan	56		
26-Jan	80		
27-Jan	106	109	2.79
28-Jan	132	143	8.63
29-Jan	170	164	3.26
30-Jan	213	212	0.33
31-Jan	259	267	3.22
1-Feb	304	311	2.22
2-Feb	361	351	2.87
3-Feb	425	422	0.78
4-Feb	490	500	2.02
5-Feb	563	559	0.69
6-Feb	636	643	1.16
7-Feb	722	714	1.13
8-Feb	811	813	0.28
9-Feb	908	908	0.05
Mean			2.10

to fight the epidemic and has continued to release relevant data since January 21, 2020. Data released after January 21 were used to test the performance of the forecasts.

A rolling forecast approach was taken in the experiment. Here, the data of every five consecutive days were used as observations to predict the data for the next day. The mean absolute percentage error (MAPE) was used to test the performance of the model. The prediction results of the confirmed cases are presented in Table 1.

As shown in Table 1, the mean MAPE is 4.66%, which meets our expectations for accurate forecasting. The FGM(1,1) model only needs five consecutive days of data to predict the next day's data. It needs very little data and

follows the principle of new information priority. Even for the most uncontrollable first days of the epidemic, FGM(1,1) showed accurate prediction. Since February 28, the predicted MAPE has been less than 10%, which demonstrates the adaptability of the model.

The number of deaths due to COVID-19 and the number of people who have recovered are shown in Tables 2 and 3, respectively.

As shown in Tables 2 and 3, the MAPE of the number of deaths and recoveries from COVID-19 was 2.10% and 3.61%, respectively. All the MAPE values of the prediction results were less than 10%, which means that the prediction results met the requirement of highly accurate prediction.

TABLE 3: Prediction of the number of people recovered from COVID-19.

Data	Actual values	FGM(1,1)	MAPE (%)
24-Jan	38		
25-Jan	49		
26-Jan	51		
27-Jan	60		
28-Jan	103		
29-Jan	124	129	3.84
30-Jan	171	169	1.00
31-Jan	243	225	7.38
1-Feb	328	318	3.01
2-Feb	475	441	7.09
3-Feb	632	646	2.28
4-Feb	892	843	5.51
5-Feb	1153	1217	5.54
6-Feb	1540	1536	0.25
7-Feb	2050	1975	3.64
8-Feb	2649	2669	0.75
9-Feb	3281	3381	3.05
Mean			3.61

TABLE 4: The forecasting results of FGM(1,1).

Data	Number of confirmed cases	Growth rate of confirmed cases (%)	Number of deaths	Number of recoveries
10-Feb	37,857	5.21	1011	4160
11-Feb	39,742	4.98	1123	5240
12-Feb	41,585	4.64	1244	6582
13-Feb	43,397	4.36	1373	8253
14-Feb	45,186	4.12	1513	10,333

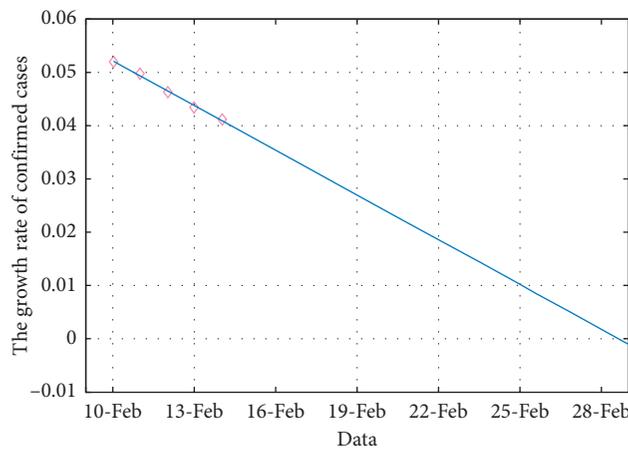


FIGURE 1: Prediction of the growth rate of the number of confirmed cases.

Therefore, we took the next step to predict the future number of confirmed, dead, and recovered cases, as shown in Table 4.

The predictions show that the growth rate of the number of confirmed cases was on the decline, and the number of recoveries was on the rise. Based on the above results, we further predicted the growth rate of confirmed cases. From the existing data, the growth rate showed a straight-line downward trend, so linear regression was used for prediction. The predictive effect is shown in Figure 1. We could draw the conclusion that the inflection point would be

reached around February 29, the spread of COVID-19 would be effectively controlled, and the number of people infected would not increase much.

4. Conclusions

The spread of COVID-19 has caused great damage to the world's health care systems, so it is very necessary to predict the spread of disease in the future. In the early stages of the outbreak, data are limited and not absolutely accurate. The FGM(1,1) model is a good choice at the early stage of disease

transmission for the prediction of trends of this new disease. FGM(1,1) is suitable for short-term prediction of time series. Using the characteristics of fractional-order accumulation, the grey model can analyze the rules in short-term data well based on the principle of new information first. Hence, FGM(1,1) could accurately predict the number of confirmed cases, the number of deaths, and the number of recoveries. The predicted results indicate that the spread of COVID-19 will be further suppressed in China, more people will be cured, and infection rates will fall further.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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