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Epidemic Prediction and Analysis of COVID-19 in Different Countries based on Neural Network

Tao Zhang

North China Electric Power University, Baoding, 071003, China.

Abstract

The COVID-19 outbreak continues to spread around the world, with more than 200 countries and regions having confirmed cases, and various responses to the outbreak. In order to predict the development trend of the epidemic in different countries and analyze the effectiveness of relevant prevention and control measures, a BP neural network (BPNN) model was established to predict the development of the epidemic in China, the United States and Italy in the next 180 days based on relevant data of the epidemic. The results show that the BP neural network model can reasonably predict the development of the epidemic. In the three samples, the cumulative number of confirmed cases in China has basically stabilized, and the peak of the epidemic in Italy and the United States will occur no earlier than mid-January next year. The prediction results of this study are basically consistent with the actual epidemic situation and the policies issued by relevant departments, which can provide a scientific basis for effective epidemic prevention and control measures.

Keywords

COVID-19, BP Neural Network, Epidemic Prediction, Epidemic Prevention and Control.

1. Introduction

Coronavirus disease 2019 (COVID-19) is caused by severe acute respiratory syndrome Coronavirus 2(SARS-CoV-2). As a class of β-coronavirus, the virus has many potential natural hosts, intermediate hosts and ultimate hosts. Due to its high infectivity and transmissibility, it rapidly led to a global pandemic and posed a serious threat to the public health system [1-3]. In order to contain the spread of the virus, China has actively carried out COVID-19 epidemic prevention and control work, including mass isolation, social isolation, community containment and traffic restriction [4]. In addition, the government has continuously increased the investment in medical resources for COVID-19 patients [5]. At present, the epidemic situation in China is obviously improving, but asymptomatic infected people have the ability to spread the virus, and their clinical symptoms are hidden but cannot be effectively identified, which is easy to form the loopholes of prevention and control measures [6-9].

What prevention and control measures should be taken to reduce the risk of infection among the population has become the focus of social attention.Therefore, by establishing a mathematical model, this study predicted the development trend of the epidemic in major countries in the world, and analyzed the epidemic prevention and control measures.

2. Materials and Methods

2.1 Source of datas

According to the national health committee's official website, https://github.com/datasets/covid-19 public epidemic data,Statistical January 22, 2020-2021 on June 19, the cumulative number of

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confirmed, cumulative death toll in mainland China, the cumulative number of cure, the cumulative number of close contacts, the cumulative number of asymptomatic infections, and the United States, Italy, the cumulative number of confirmed, accumulative total deaths, total number of cure, and modeling based on depth of learning.

2.2 Model building and data analysis

In this paper, a three-layer BP neural network is built through MATLAB software, including input layer (X), hidden layer (H) and output layer (Y). As shown in Figure 1, this model can self-learn according to updated epidemic data, adjust internal weight parameters, and has good ability of recognition, training and fault tolerance. The number of input and output nodes is defined as 1, with time as the input node and the confirmed number of people as the output node. Through the empirical formula, the number of hidden layer nodes is set as 5, the target error is set at 0.0005, and the number of iterations is 150. After several times of fitting, the selected learning efficiency is 0.12, and the prediction accuracy of the model is high. Using BP neural network in the evaluation of complex systems with the evaluation of the advantages of high precision, considering the three respectively adopted different degree of isolation measures the national epidemic data of samples, according to the result of data fitting, isolation measures to strictly, China, Italy isolation measures strictly for general, the isolation measures is not strict. In this modeling process, we trained the confirmed epidemic data of 22 January 2020 solstice and 19 June 2021 in three countries and predicted the epidemic data of the three countries in the next 180 days. In view of the small data sample, the training data and test data in this paper remain consistent and are all data sets, so as to verify the prediction accuracy of the model.

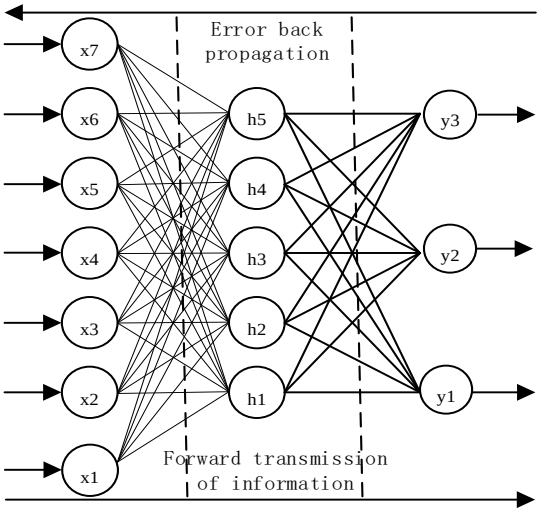

Fig. 1 BP neural network structure principle

2.3 Statistical analysis platform

In this study, Matlabr2018 and Python 3.7.0 simulation platform were used for analysis.

3. Simulation results

This study counted the cumulative number of confirmed cases as of January 22, 2020 solstice and June 19, 2021 as officially reported in China, Italy and the United States. Each country contains 515 data, and the training data and test data are the same as the whole data set, so as to verify the prediction accuracy of the model. The relative error of model prediction is analyzed, and the relative error tends to zero in the later stage of model training. The results showed that the number of people diagnosed with COVID-19 predicted by BP neural network was basically consistent with the actual number of people diagnosed with COVID-19 in the earlier known stage. The model can reasonably predict the development trend of the epidemic in China, the United States and Italy.

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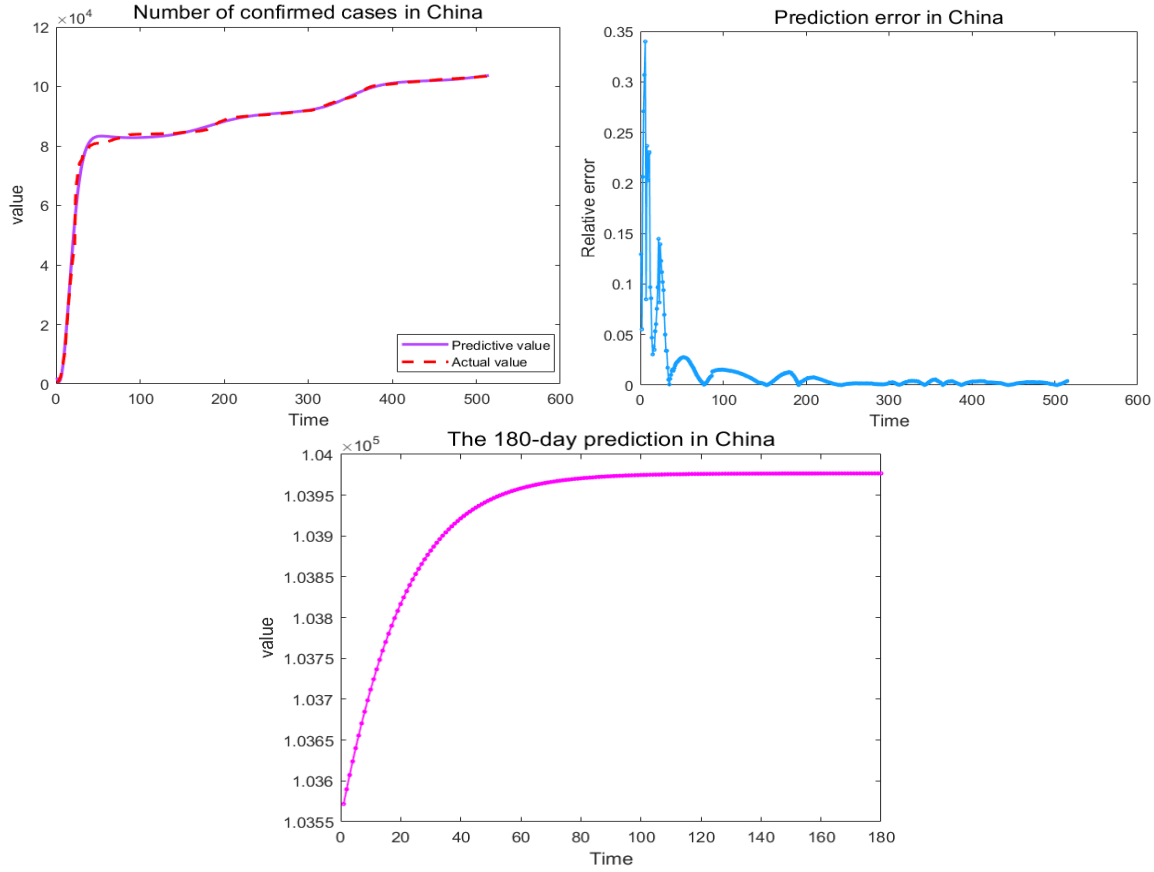

Fig. 2 Epidemic prediction model analysis in China

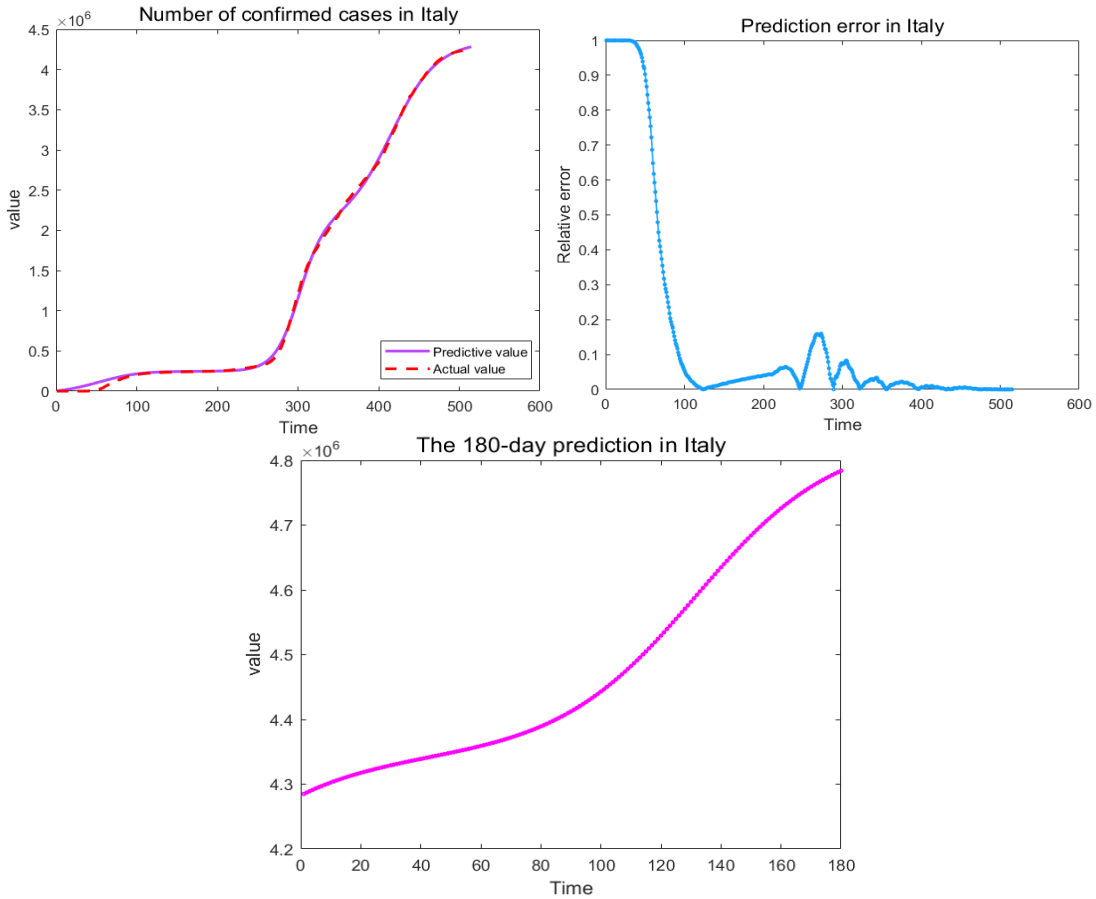

Fig. 3 Epidemic prediction model analysis in Italy

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In Figure 2, the comparison of the training set and test set of the prediction model, the relative error trend of the model, and the forecast data of the next six months are shown from left to right respectively. It can be seen that China's epidemic prevention and control measures have achieved remarkable results, and the epidemic situation has stabilized at present. It is expected that the epidemic will peak around 120 days later, and the estimated total number of confirmed cases is about 104,000.

In Figure 3, the comparison of the training set and test set of the prediction model, the relative error trend of the model, and the forecast data of the next six months are shown from left to right respectively. It can be seen that the epidemic prevention and control measures in the early stages in Italy has good effect, but as the return to work and production, epidemic situation is more serious, is expected to also won't peak after 180 days, The estimated cumulative number of people diagnosed after 180 days is about 484,000.

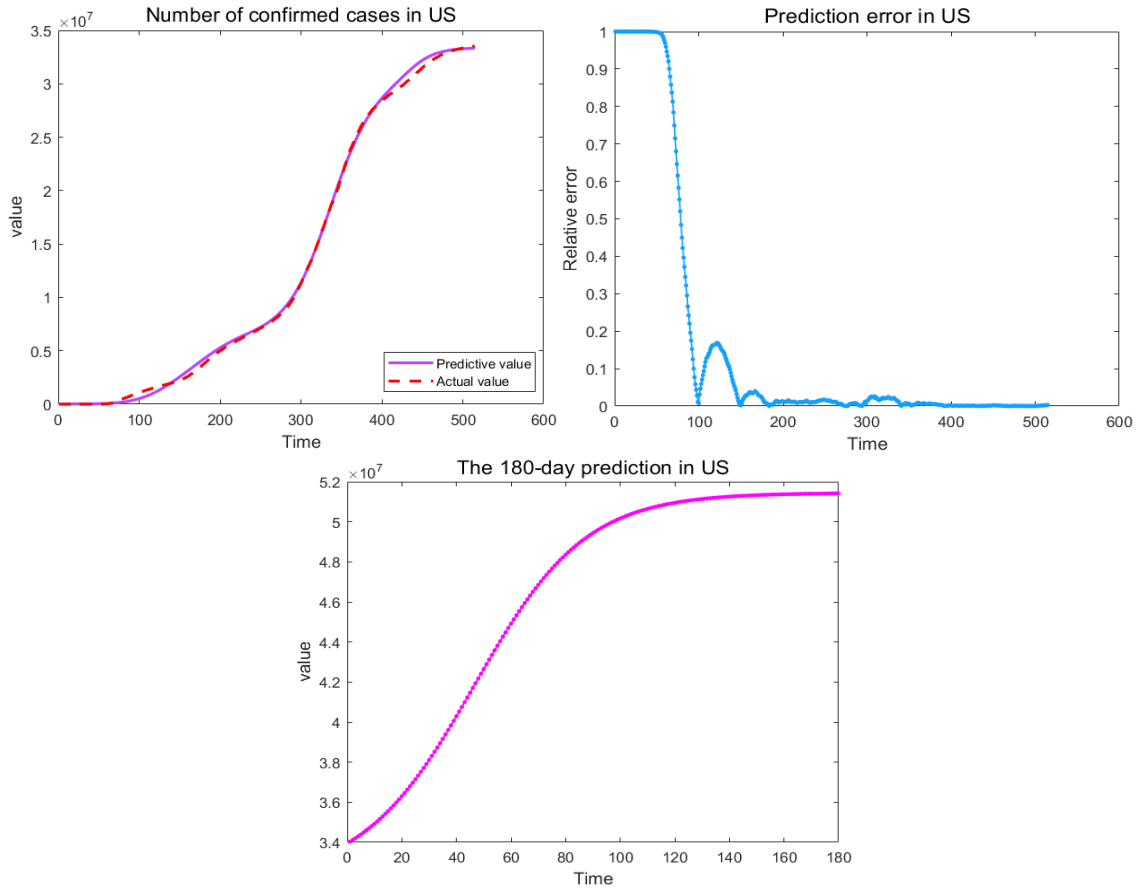

Fig. 4 Epidemic prediction model analysis in the United States

In Figure 4, the comparison of the training set and test set of the prediction model, the relative error trend of the model, and the forecast data of the next six months are shown from left to right respectively. It can be seen that the epidemic prevention and control measures in the United States have not had a good effect. As far as the number of confirmed cases are concerned, the epidemic situation is grim at present and is expected to reach a peak in 180 days.The estimated cumulative number of people diagnosed after 180 days is about 52 million.

4. Discuss

Compared with SARS and MERS, although COVID-19 has a lower mortality rate, it is significantly more infectious [10]. Since the Diamond Princess of Japan found a large number of COVID-19 infections, the outbreak has been confirmed in many countries around the world, and the situation has

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become increasingly serious, which has caused serious damage to the health systems and economies of various countries. Since the outbreak of COVID-19, a number of studies at home and abroad have proposed a dynamic model of infectious diseases, which can scientifically predict the development trend of the epidemic based on the relevant data of the epidemic, and provide an important basis for the decision-making of public health managers and the implementation of efficient intervention measures [10-15]. Fan RuGuo et al. [12] established the SEIR infectious disease dynamic model, and predicted the inflection point of the epidemic in Wuhan and the peak of the number of confirmed COVID-19 cases under three different incubation periods. Wei Fengying et al. [13] studied and judged the overall situation of major affected countries in the world with SEIR model, and carried out numerical simulation on the possible impact of resuming work and production on the development of the epidemic. Omar et al. [10] used a time series model and curve fitting to assess the number of confirmed COVID-19 cases in India in the next 30 days and to test the effectiveness of isolation measures. Chimmula et al. [14] used the LSTM model to predict the time series of COVID-19 transmission in Canada, and compared the transmission rates in Canada, Italy and the United States.

Some studies also used LSTM model based on cyclic neural network to predict the future mutation rate of SARS-CoV-2 [15]. However, most of these studies are based on the early data of the epidemic, focusing on the peak of the epidemic, the inflection point, the transmission rate and the effectiveness of prevention and control measures, without further analysis of the prevention and control measures.

This study used the latest epidemic data to build a BP neural network model to analyze the epidemic situation in three countries with different levels of quarantine (China, Italy and the United States), and to predict the cumulative number of confirmed cases in the next six months. The epidemic situation in China has stabilized and there will be no "second peak". At the beginning, Italy took prevention and control measures, such as suspending school and blocking traffic, and the prevention and control effect of the epidemic was good. However, there was some relaxation later, and the peak time of the cumulative number of confirmed cases was not determined. Despite the late emergence of the epidemic in the United States, the prevention and control measures are not strict enough. It is estimated that the peak time of the cumulative number of confirmed cases will not be less than half a year. A comparative analysis of the trends of the epidemic in the three countries shows that China has made significant strategic achievements in its epidemic prevention and control efforts. On this basis, enterprises and institutions are also accurate and orderly resumption of work and production. So a bigger concern for the country at this stage is the resumption of big sporting events, concerts and business gatherings.

5. Conclusion

The BP neural network adopted in this paper has strong nonlinear mapping ability, self-learning ability, generalization ability and fault tolerance ability. These advantages make it widely used in epidemic prediction of infectious diseases, clinical diagnosis and treatment analysis of diseases. However, with the gradual expansion of application scope, BP neural network also exposed some shortcomings, including local minimization and sample dependence. To sum up, the results of the model and the actual epidemic trends agreed policies and related departments, can provide theoretical reference for college next resumption plan schooling, at the same time can be further extended to large sporting events, concerts, business meetings, such as restart time analysis, stimulate consumption, promote economic recovery even further.

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