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Research on Vespa Mandarinia Species Invasion Prevention and Control Based on Gray Prediction Model

Liu Huanyu, Zha Shi Ci Li, Jiang Wang

School of management science and engineering, Central University of Finance and economics, Beijing, 102200

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Abstract: For the Washington state, the existence of Vespa mandarinia may do harm to the local people and the environment. Therefore, according to the eyewitness reports collected by government, we establish several prediction models and classification models to help the government better deal with the harm caused by the bees. We process the data and remove some possible exception value.Then we respectively use the gray prediction model to predict the longitude and latitude, and get the latitude and longitude information of the reports that are confirmed to be the Vespa mandarinia for the next four times, and give the predictions Accuracy. We find that the bee colony moved roughly to the southeast and inland.

1. Introduction

In 2019, Vespa mandarinia has been found in British Columbia, Canada. Although people have made rapid efforts to destroy their nest, people in neighboring Washington State have also witnessed the existence of Vespa mandarinia.This kind of insect is native to Japan, China and other tropical or temperate East Asian regions. Like many social wasps, it is a predator of other insects (even honey bees).

The existence of Vespa mandarinia may bring great harm to the surrounding environment. For instance, a few Vespa mandarinia can destroy a large colony of European honeybees in a short time. Moreover, Vespa mandarinia may also cause some casualties. According to the report, about 50 people die every year due to the sting of Vespa mandarinia which will induced allergic reactions and even multiple organ failure. Because of the potential dangers of Vespa mandarinia, Washington State provides people with ways to report sightings of these hornets. It is an urgent and a beneficial goal to improve the reporting method and optimize the investigate way.

2. Predict the spread of Vespa mandarinia

2.1 Data Processing

According to the document, the latitude and longitude of 14 positive IDS are statistically analyzed with the data provided. It is found that the latitude range of these verified Vespa mandarinia is [48.7775, 49.1494], and the longitude range is [- 123.94313, - 122.4186]. We find that the verified reports of Vespa mandarinia are only a small part of all the reports.

In addition, we can find that the points (49.149394, -123.94313) and (48.777534, -122.418612) are far away from other sample points by observing the picture. Through calculation, it is obtained that the closest distance between the point (49.149394, -123.94313) and other points is 83.601 kilometers, and the observation on the map shows that the point is separated from other points by a strait. Similarly, the closest distance between the point (48.777534, -122.418612) and other points is 29.127 kilometers, which is close to the nesting distance of a new queen of Vespa mandarinia, but no more reports of Asian hornets are found nearby. It shows no spatial density. Therefore, we believe that these two points will seriously affect the accuracy of the prediction model, and these two points are not considered in the model. We arranged 12 positive IDS in chronological order, used the serial number as the independent variable, and used the grey prediction model to predict the transmission range, and judged whether the transmission of Vespa mandarinia could be predicted in a certain time by the accuracy of the prediction.

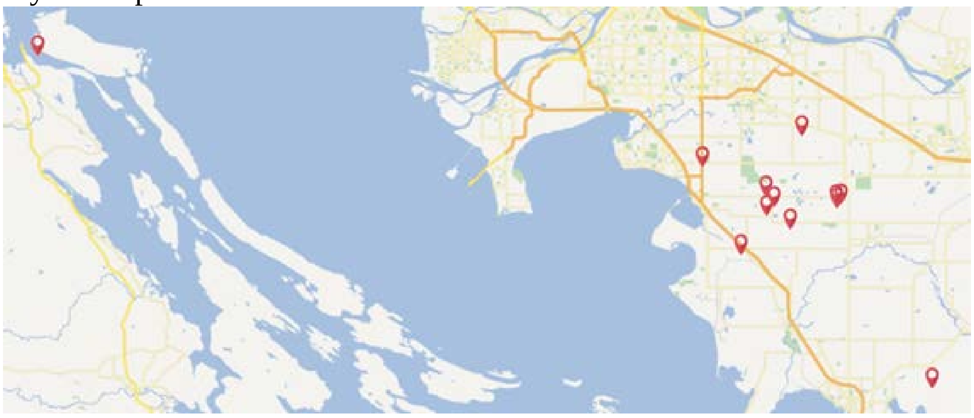

Figure 1: Report Distribution

2.2 GM Model

Grey system is a system that contains both known and unknown information.And the grey prediction model is a prediction model for the grey system. [1] We use GM (1,1) model, which means to use the First Order Differential Equation to model a variable. The purpose of the grey prediction model is to regard the discrete data scattered on the time axis as a group of continuous changing series, weaken the unknown factors in the grey system and strengthen the influence degree of the known factors by means of accumulation. Finally, a continuous differential equation with time as the variable is constructed, and the parameters in the equation are determined by mathematical methods, so as to achieve the purpose of prediction. [2]

We define a as development coefficient and u as grey action quantity, and the matrix composed of a and u is called grey parameter.

1. Accumulate the original data to weaken the randomness and volatility of the original data.

Set the original data be $x^{(0)} = (x^{(0)}(1), x^{(0)}(2), \dots, x^{(0)}(n))$, where n=14.The new sequence obtained by accumulation is $x^{(1)} = (x^{(1)}(1), x^{(2)}(2), \dots, x^{(1)}(n))$, where $x^{(1)}(k) = \sum_{i=1}^{n} x^{(0)}(i), k = 1,2, \dots, n$.

2. Establish the first order differential equation with one variable is established based on the grey theory.

Generate the sequence related to

$$x^{(1)}: z^{(1)} = \{z^{(1)}(2), z^{(1)}(3), \dots, z^{(1)}(k)\}, k = 2,3, \dots, n$$

Where

$$z^{(1)}(k) = 0.5x^{(1)}(k-1) + 0.5x^{(1)}(k), k = 2,3,\ldots,n$$

And then establish the first order differential equation of one variable G(1,1).

$$\frac{\boldsymbol{dx^{(1)}}}{\boldsymbol{dt}} + \boldsymbol{ax^{(1)}} = \boldsymbol{u}$$

3. The mean value of accumulated data is used to generate B and constant vectors $\boldsymbol{Y_n}$.

$$\boldsymbol{B} = \begin{pmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \vdots & \vdots \\ -z^{(1)}(n) & 1 \end{pmatrix} = \begin{pmatrix} -0.5(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -0.5(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \vdots & \vdots \\ -0.5(x^{(1)}(n-1) + x^{(1)}(n)) & 1 \end{pmatrix}$$

$$\boldsymbol{Y_n} = \begin{pmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \vdots \\ x^{(0)}(n) \end{pmatrix}$$

4. The grey parameters are solved by least square method,and the predicted values are obtained by reduction.

$$\hat{a} = (B^T B)^{-1} B^T Y_n$$

We bring the grey parameters into the differential equation and solve it, get $\boldsymbol{x^{(0)}(t+1)} = \boldsymbol{x^{(1)}(t+1)} - \boldsymbol{x^{(1)}(t)}$. And we obtain predicted values by reducing the structure.

3. Model Solving

1. Prediction of latitude change with time

We use the GM model to predict the latitude of the next four times of Vespa mandarinia discovery, and the predicted values are 48.972,48.9698,48.9676,48.9654 respectively.

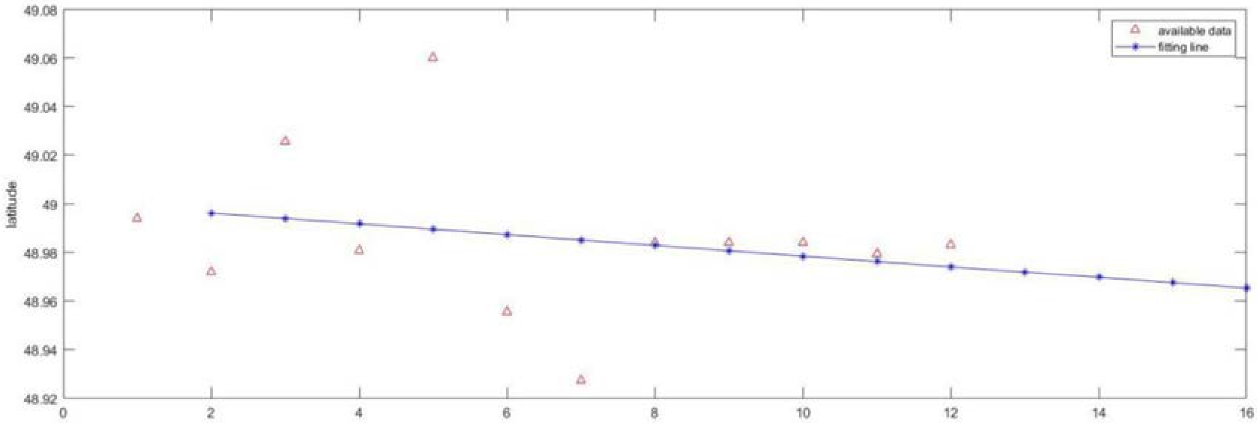

Figure 2: Latitude Change

2. Prediction of longitude change with time

Then we predict the longitude of the next four Vespa mandarinia discoveries, and the predicted values are-122.5358, -122.5170, -122.4982, -122.4794 respectively.

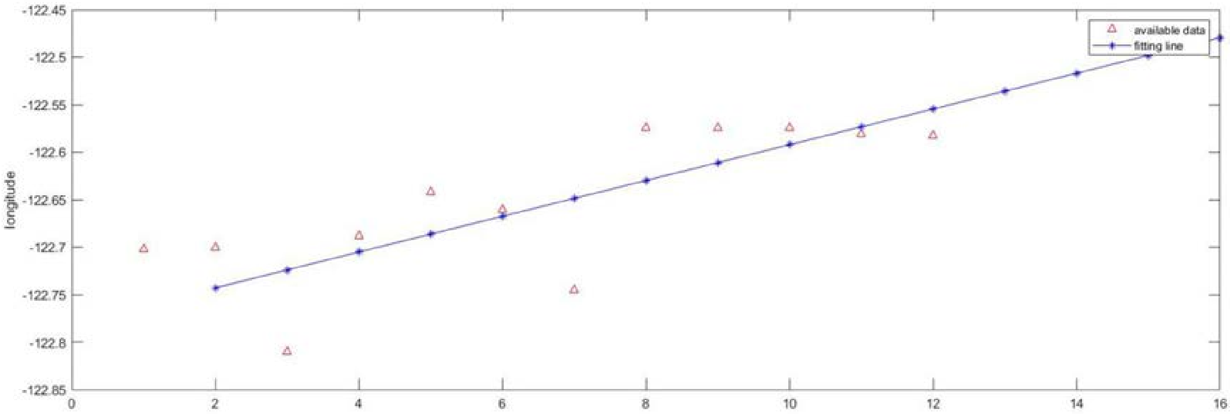

Figure 3: Longitude Change

The percentage absolute error of latitude and longitude prediction is 0.042022% and 0.05397% respectively, which can be called the prediction with good accuracy. Through the fitting line, we know that with the passage of time, the C moves slowly to lower latitudes and east.

4. Conclusion

The algorithm used in our model has been widely used in various fields, so our model can not be limited to this problem. For example, the model can not only be applied to the prediction and identification of other pests in the same field, but also to the prediction and prevention of environmental disasters such as fire. [3]According to statistics, there are about 200000 forest fires in the world every year. If we can establish a system to reduce the probability of fire, it will undoubtedly be extremely beneficial in any aspect.

References

[1] Zeng Bo, Li Hui, Ma Xin A novel multi-variable grey forecasting model and its application in forecasting the grain production in China [J] Computers & Industrial Engineering, 2020, 150

[2] Luo Xilin, Duan Huiming, Xu Kai A novel grey model based on traditional Richards model and its application in COVID-19 [J] Chaos, Solitons & Fractals, 2020(prepublish)

[3] Song Yoonho. Tutorial on the Coordinate Transforms in Applied Geophysics [J]. Geophysics and Geophysical Exploration, 2020, 23(2).