2018 Mathematical Contest in Modeling (MCM) Summary Sheet

Title Improved Aka drug differential equation propagation model based on infectious disease model

Summary

Opioid crisis has had a huge impact on the society of US. Based on the similarity of the spread characteristics of opioid and infectious diseases, we establish a differential equation model based on infectious disease models and analyze its characteristics.

To further analyze the relationship between the spread of opioid and US socio-economic indicators, we conduct an R-type cluster analysis on all Ohio indicators, and divide them into five categories, get one from each of the categories as representative. With the correlation analysis, it is concluded that education experience has a strong correlation with the spread of opioid.

For further analysis, we get an improved differential equation model for the actual spread of drugs by modifying the daily infection rate from an constant to a variable changes with time. Finally, we simulate the interference of national policy on the model then establish a gray-RBF neural network prediction model to test the differential equation model and give some strategies.

Key words: Differential equation model; R-type cluster analysis; Related analysis; Grey-RBF neural network model

Contents

1. Problem statement

National crises about the use of synthetic and non-synthetic opioids are coming to the United States, so federal organizations such as the US Centers for Disease Control (CDC) are working to save lives and prevent the negative impact of the epidemic on health and the national economy. As part of the DEA Transfer Control Office, the DEA/National Forensic Laboratory Information System (NFLIS) has published a data-intensive annual report. "The database within NFLIS includes data from crime laboratories that process approximately 88% of state and local drug cases in the country each year.

This issue focuses on individual counties located in five US states: Ohio, Kentucky, West Virginia, Virginia, and Pennsylvania. Several data sets of drug identification count data sets for anesthesia analgesics (synthetic opioids) and heroin from five states were presented. Drug identification occurs when a law enforcement agency submits evidence to a crime laboratory as part of a criminal investigation and the forensic scientist in the laboratory tests the evidence. Typically, when law enforcement agencies submit these samples, they provide location data (counties) and their incident reports. When the evidence is submitted to the crime laboratory and the location data is not available, the crime laboratory uses the location of the city/county/state investigation law enforcement organization that submitted the case.

➢ Question 1

Using the provided NFLIS data, a mathematical model was created to describe the spread and characteristics of synthetic opioids and heroin events (cases) between the five states and their counties. Also identify any possible locations where specific opioids may have begun to be used in five states. The problems that the US government will have when envisioning patterns and features that continue to exist. And predict that when these conditions occur at these drug recognition threshold levels, the model will need to be able to predict when and where they will occur in the future?

➢ Question 2

Use the provided socio-economic data creation model to address the following questions:
Explain the development of opioids, what contributed to the use of opioids and the growth of addiction, and why the use of opioids still exists. Is the use or use trend related to any US Census socioeconomic data provided? If so, please modify the mathematical model in question one.

➢ Question 3

Combine the results of Questions 1 and 2 to identify possible strategies for combating the opioid crisis. Use this model to test the effectiveness of the strategy; identify any important parameter boundaries on which success (or failure) depends.

2. Problem analysis

2.1 Analysis of Specific Issues

The topic asks for analysis of opioid drug case data in five US states, models the drug-distribution process, and combines socio-economic factors in the state, corrects the model, analyzes the characteristics of the opioid-drug-distributing process, and provides effective policy providers. Strategy to deal with "Opioid Crisis". In response to the problem, the states are taken as nodes and combined with socio-economic data. The specific analysis ideas are as follows:

2.1.1 Analysis of Problem 1

The infectious disease model was extended to the drug-distribution analysis model to establish a differential equation model for opioid-like drug propagation, and the characteristics of the drug-distribution process and related thresholds were analyzed based on the model parameters.

2.1.2 Analysis of Problem 2

To analyze the impact of socio-economic factors in the state on the incidence of opioid cases in the state, cluster analysis was used to classify a large number of socio-economic characteristics and extract representative characteristics, and analyze the socio-economic factors affecting the development process of "Opioid Crisis". The first model was revised.

2.1.3 Analysis of Problem 3

The inter-state data correlation prediction was performed on the same time section using the gray RBF neural network combination model, that is, the current state case rate was obtained by the case rate prediction of other states to test the model one and the second model. For the first three models, the strategy of confronting "Opioid Crisis" is proposed, and the influencing factors and corresponding thresholds that determine the success or failure of the strategy are analyzed.

3. Basic assumption

➢ Assume that the total number of people in the area examined during the Aka drug transmission period remains the same, regardless of birth rate and mortality, nor birth rate and mortality.

➢ The data provided by the five states from 2010 to 2017 can better reflect the trend of the total number of Aka drugs in each state in the short term, that is, there is no extreme value.

➢ After R-type clustering of all socio-economic data, the indicators selected from each category can accurately represent and reflect each category.

➢ For some missing data, the filling is fair and reasonable, and does not affect the overall.

➢ The data found is true and reliable.

4. Glossary & Symbols

Symbol	Definition
λ	Daily infection rate
M	Daily cure rate
r	Correlation coefficient
x_i	I-th socioeconomic indicator
SSE	Sum of squared residuals
N	Total number of patients in Ohia

5. Models

5.1 Analysis and Solving of Question One

5.1.1 Model Preparation

Assume that the total number of people in the area examined during the period of Aka drug transmission remains unchanged, regardless of birth rate and mortality, or population migration. The population is divided into two categories: no taking Aka and taking Aka. , hereinafter referred to as healthy people and patients. And at the time t, the proportion of these two groups of people in the total number N is s(t) and i(t). The average number of people who can effectively contact each patient every day and make healthy people take Aka drugs is constant λ. λ is called the daily contact infection rate, which means that when the patient is in effective

contact with the healthy person, the healthy person is infected and becomes a patient. The proportion of patients who are cured every day is a constant μ, called the daily cure rate, which can be expressed as the proportion of successful people who are detoxified every day. In particular, patients can still take Aka drugs repeatedly after the patient is cured. It is obvious that $1/\mu$ is the average infection period during the drug's transmission period. In this way, we can establish a differential equation model for the spread of Aka drugs similar to the model of infectious disease transmission.

5.1.2 Model Establishment

Step1: Establish differential equations based on the characteristics of Aka drugs

$$\begin{cases} N\dfrac{di}{dt} = \lambda N S(t)i(t) - \mu N i(t) \\ s(t) + i(t) = 1 \end{cases} \tag{1}$$

Step2: Further simplification

$$\begin{cases} \dfrac{di}{dt} = \lambda i(t)[1 - i(t)] - \mu i(t) \\ i(0) = i_0 \end{cases} \tag{2}$$

Step3: Know the results

$$i(t) = \begin{cases} \left[\dfrac{\lambda}{\lambda-\mu} + \left(\dfrac{1}{i_0} - \dfrac{\lambda}{\lambda-\mu}\right)e^{-(\lambda-\mu)t}\right]^{-1} & \lambda \neq \mu \\ \left(\lambda t + \dfrac{1}{i_0}\right)^{-1} & \lambda = \mu \end{cases} \tag{3}$$

Step4: Defining σ=λ / μ, noting the meaning of λ and 1/μ, we can see that σ is the ratio of the daily infection rate to the daily cure rate during the whole propagation period, called the number of contacts. With σ, the model can be rewritten as:

$$\frac{di}{dt} = -\lambda i(t)\left[i(t) - \left(1 - \frac{1}{\sigma}\right)\right] \tag{4}$$

Step5: Separate variables and further simplify

$$\frac{di}{i(t)\left[i(t) - \left(1-\frac{1}{\sigma}\right)\right]} = -\lambda\, dt \tag{5}$$

Step6: Find the points on both sides and solve them.

$$i(t) = \frac{1 - 1/\sigma}{e^{-\lambda t\left(1-\frac{1}{\sigma}\right)} + c} \quad \textbf{（c is the parameter）} \tag{6}$$

5.1.3 Model solving

（1）Figure 1 shows the relationship between the total number of patients in five continents

over time, and Figure 2 shows the geographical relationship between the five continents. It can be seen from the figure that the total number of patients in Ohia has been increasing, and the total number of patients in Pennsylvania is decreasing. The trend of the total number of patients in the other three states over time is not very obvious.
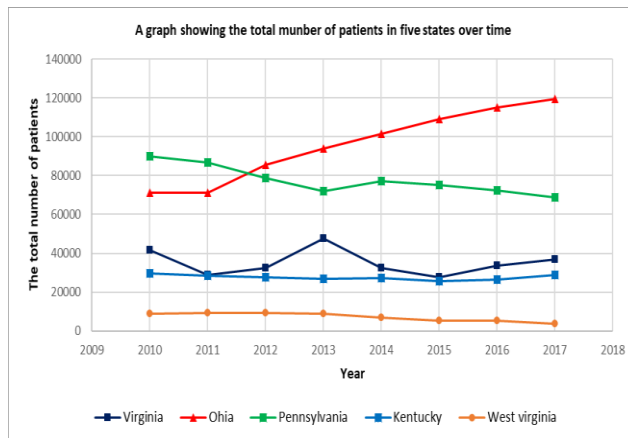

fig1.The total number of patients in five states over time   fig2 .The geography of the five continents

（2）The analysis shows that the rule of Aka drug propagation process is the same between

different states. In order to make the description law more significant, the formula (6) is solved by using Ohia data as an example, and solved by Matlab software. , so that the sum of squared residuals is the smallest, that is to say.

Obtain：

$$\lambda = 0.7, \mu = 0.556, \sigma = 1.259, c = 1.5，\text{ SSE}=0.000014.$$

The function of the Aka drug infection rate in Ohia over time is

$$i(t) = \frac{0.0206}{e^{-0.01442t}+1.5} \qquad (7)$$

5.1.4 Analysis of the Result

（1）From σ=1.259, λ >μ, the daily contact transmission rate of the opioid-like drugs is greater

than the daily cure rate, which is consistent with the increasing trend of the opioid drug infection rate in Ohia Prefecture from 2010 to 2017, and the residual square sum SSE=0.000014 is extremely small. , indicating that the model has a good fit

（2）The analysis shows that the contact number σ=1 is a threshold. When σ>1, the increase

and decrease of i(t) depends on the size of i_0, but its limit value $\lim\limits_{i \to \infty} i = 1 - \frac{1}{\sigma}$ increases with

the increase of σ; When σ ⩽ 1, the proportion of patients i(t) is getting smaller and smaller, and

eventually tends to 0. This is because the number of healthy people who become patients during

the transmission period does not exceed the original number of patients.

（3）In this way, the US government needs to pay special attention to the critical value σ. When the number of patients increases with σ>1, the social security situation may be worsened, taking into account the ratio of the number of Aca drugs taken to the total number of Aka drugs. Stable in the short term, and the cure rate, that is, the compulsory detoxification rate, is basically unchanged under certain government policies (such as social security). All of us can estimate the total infection rate λ according to the usage rate of specific Aka drugs. Compared with the cure rate μ, for example, when λ>μ, the number of patients will increase, and the government needs to develop measures such as strengthening social security. Taking Ohia as an example, it can be seen from Table 2 that the number of patients in Heroin accounts for the total number of people is 30.5%, so that the total number of patients and the infection rate can be estimated accurately based on the number of patients in Heroin, and then analyzed with the critical value, so that the problem is well solved.

Table1.The percentage of all drug sick in 2010 Ohia

Name	Heroin	Methadone	Morphine	…	Oxycodone	Buprenorphine
Percentage	0.305	0.0246	0.0209	…	0.122	0.377

5.2 Analysis and Solving of Question Two

5.2.1 Model Preparation

According to the analysis of the socio-economic data provided by the US population, there are too many analytical indicators. There are 149 effective analysis index categories after pre-processing, and there is a strong correlation between each index. This systematically analyzes and studies the society. The relationship between economic data and the spread of Aka drugs has caused great difficulties. Therefore, we first conduct R-type cluster analysis on 149 social and economic indicators, and classify highly relevant economic indicators into several categories to identify the main factors affecting the spread of opioids. In this way, we can select representative indicators from various analysis indicators, and then analyze the selected social and economic indicators and the spread of Aka drugs. Among them, $x_1, x_2, …, x_{149}$ respectively represent 149 people's census social and economic indicators

5.2.2 Model Establishment And Solving

(1) Establishment and Solution of R-Type Cluster Analysis
Step1: The correlation coefficient is used to measure the correlation of the variables Record the value of the variable x_j（$x_1, x_2, …, x_j$）$^T \in R^n$(j=1,2,...,m), then the sample correlation coefficients of the two variables x_j and x_k can be used as their similarity measure,

$$r_{jk}=\frac{\sum_{i=1}^{n}(x_{ij}-\overline{x_J})(x_{ik}-\overline{x_k})}{[\sum_{i=1}^{n}(x_{ij}-\overline{x_J})^2\sum_{i=1}^{n}(x_{ik}-\overline{x_k})^2]^{\frac{1}{2}}}$$ (8)

Step2: The shortest distance method is used to cluster the variables, and the distance between the two types of variables is defined as,

$$R（G_1,G_2）=\min|d_{jk}|$$

among them: $d_{jk}=1-|R_{ij}|$ or $d_{jk}{}^2=1-r_{jk}{}^2$, at this time, $R（G_1,G_2）$ correlation with the similarity measure between the two most similar variables in the two categories.

Step3: Correlation analysis of Ohia's 149 people's census social economic data indicators is conducted, and a correlation coefficient table between various factors is obtained.

Table1. Table of correlation of 149 analytical indicators

	x_1	x_2	x_3	…	x_{147}	x_{148}	x_{149}
x_1	1	0.9945	0.9888	…	0.8368	0.8117	0.6925
x_2	0.9945	1	0.9967	…	0.8297	0.8282	0.6598
x_3	0.9888	0.9967	1	…	0.8087	0.8179	0.6654
…	…	…	…	…	…	…	…
x_{147}	0.8368	0.8297	0.8087	…	1	0.7261	0.6413
x_{148}	0.8117	0.8282	0.8179	…	0.7261	1	0.3962
x_{149}	0.6925	0.6598	0.6654	…	0.6413	0.3962	1

Step4: The 149 variables were systematically clustered by the maximum coefficient method. The classification results are shown in Fig. 3.
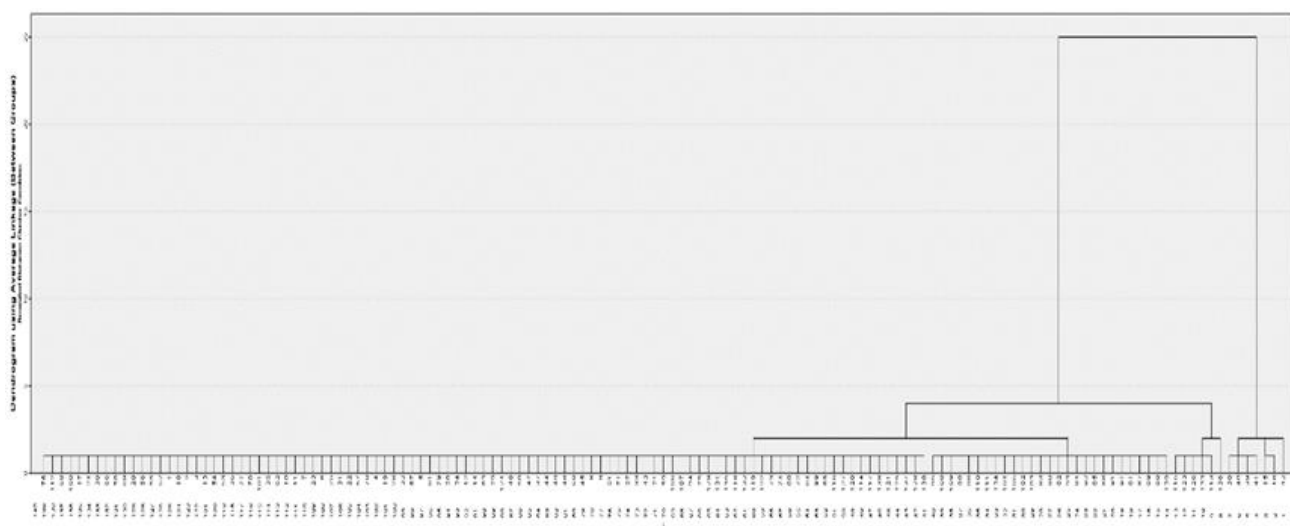
fig3. Clustering figure

Use w_1, w_2,... w_{149} to represent each node on the cluster map, and record $\Omega = \{ w_1, w_2, ... , w_{149}\}$.

When the distance value $f=2$, it is divided into five categories, namely

$$G_1 = \{w_{38}, w_{39}, w_{40}, w_{41}, w_{42}\}, G_2 = \{w_{15}, w_{16}\}$$

$$G_3 = \{w_{113}, w_{115}, w_{123}, w_{126}, w_{133}, w_{136}\},$$

$$G_4 = \{w_{95}, w_{108}, w_{109}, w_{98}, w_{110}, w_{111}, w_{134}, w_{104}, w_{105}, w_{102}, w_{103}, w_{83},$$

$$w_{90}, w_{82}, w_{93}, w_{85}, w_{86}, w_{91}, w_{97}, w_{87}, w_{89}, w_{88}, w_{139}\}$$

$$G_5 = \{w_{76}, w_{58}, w_{130}, ...\}$$

among this $G_5 = \Omega - （G_1 + G_2 + G_3 + G_4）$.

The analysis shows that the first category reflects fertility information, the second category mainly reflects Average household size and Average family size information, the third category mainly reflects the information about the birthplace and the mother tongue, and the fourth category mainly reflects the year of entry. The fifth category mainly reflects information about the Year of entry and the level of education. So we select 5 analytical indicators from 149 indicators, which are $x_{42}, x_{15}, x_{113}, x_{88}, x_{64}$.

（2）Related analysis

Now we have a correlation analysis between the relationship between the analysis indicators $(x_{15}, x_{42}, x_{64}, x_{88}, x_{113})$ and the number of Aka drug transmissions (y).

Table2. Ohia's five evaluation indicators and the total number of patients

	2010	2011	2012	2013	2014	2015	2016
x_{15}	221.3	218.81	221.37	222.57	221.32	220.85	220.63
x_{42}	130349	129855	153278	125586	145998	139586	1435739
x_{64},	153782	150359	130349	126298	123940	122551	121848

x_{88}	78425	79963	84566	81626	92519	86580	90673
x_{113}	915914	939454	949903	968771	979239	975437	912807
y	70999	71282	85415	93747	101423	109150	115276

Step1: Calculate the average of five analytical indicators and the number of Aka drug transmissions

$$\overline{x_{42}}, \ \overline{x_{15}}, \ \overline{x_{113}}, \ \overline{x_{88}}, \ \overline{x_{64}}, \ \overline{y}$$

Step2: Calculate the Person correlation coefficient using the formula

$$rx_i y_1 = \frac{\sum_{j=1}^{n}(x_{ij}-\overline{x_i})(y_{1i}-\overline{y})}{\sqrt{\sum_{j=1}^{n}(x_{ij}-\overline{X_i})^2 \sum_{i=1}^{n}(y_i-\overline{y})^2}} \tag{9}$$

Correlation coefficient table

Table3. Correlation coefficient table

	x_{15}	x_{42}	x_{64}	x_{88}	x_{113}	y
x_{15}	1					
x_{42}	-0.13401	1				
x_{64}	-0.43901	-0.36292	1			
x_{88}	0.100381	0.48748	-0.8024	1		
x_{113}	0.328978	-0.57424	-0.51013	0.298602	1	
y	0.262012	0.579961	-0.92325	0.732652	0.284207	1

5.2.3 Analysis of the Result

1）It can be seen from the correlation coefficient table $r_{\overline{x_{64}}}y$= -0.92325, | $r_{\overline{x_{64}}}y$|>0.8,so there is a high correlation and a negative correlation between x_{64} and y. According to the analysis, the number of patients in Ohia increases as people's education level decreases.

2) Further analysis of the reasons, the total number of patients changes with the degree of education of the population, probably because people will consciously reject Aka drugs as their cognitive level increases. At this time, the infection rate λ will also decrease. In this case, the assumption that the infection rate λ is constant in the first differential equation model is incorrect. Therefore, we need to correct the model one.

3) Correction of model one.

① From the previous analysis, the infection rate λ is not a constant, so we can make λ=h(t), which is expressed as a function of the infection rate as a function of time. At this time, the formula (1) should be modified to

$$\begin{cases} N\dfrac{di}{dt} = h(t)Ns(t)i(t) - \mu Ni(t) \\ s(t) + i(t) = 1 \end{cases} \tag{10}$$

②We can analogize to the Logistic model and make a bold assumption about h(t), let λ=a+bt(a, b be a parameter). At this point, the differential equation should be,

$$\begin{cases} N\dfrac{di}{dt} = (a + bt)Ns(t)i(t) - \mu Ni(t) \\ s(t) + i(t) = 1 \end{cases}$$ （11）

Simplified

$$\frac{di}{dt} = (a + bt)[1 - i(t)] - \mu i(t)$$ (12)

This is the improved differential equation model.

5.3 Analysis and Solving of Question Three

5.3.1 Model Preparation

1）Based on the above two time series models, the grey RBF neural network combined interstate space prediction model is established. The number of cases in a certain state is predicted by the number of cases in other states at the same time section, and the time series model is cross-tested. The gray system mines valuable internal laws by generating and developing some known information. Set the system characteristic data sequence:

$$x^{(0)} = (x^{(0)}(1), x^{(0)}(2),\dots, x^{(0)}$$ (13)

2）Is the original sequence, where $x^{(0)}(1), x^{(0)}(2),\dots, x^{(0)}(n)$ represents the n variables of the

decision attribute Observed value

（1—AGO）：$x^{(1)} = (x^{(1)}(1), x^{(1)}(2),\dots, x^{(1)}(n))$ (14)

3）Where $x^{(1)}k = \sum_{i=1}^{k}(x^{(0)}(i))$, $k = 1,2\dots n$ pairs to generate sequence $x^{(1)}$ Establish differential equations:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b$$ (15)

4)The parameter column c of the equation is $(a, b)^T$, and the approximate value can be obtained by the least squares method.

$$c = (B^T B)^{-1} B^T Y_n$$

Where B, Y_n is

$$B = \begin{bmatrix} -\frac{1}{2}(x^{(1)}(1) + x^{(1)}(2)) & 1 \\ -\frac{1}{2}(x^{(1)}(2) + x^{(1)}(3)) & 1 \\ \dots & \dots \\ -\frac{1}{2}(x^{(1)}(n-1) + x^{(1)}(n)) & 1 \end{bmatrix}, Y_n = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \dots \\ x^{(0)}(n) \end{bmatrix}^T$$

The solution to this equation is: $x^{(1)}(t + 1) = \left(x^{(1)}(1) - \frac{b}{a}\right)e^{-at} + \frac{b}{a}$ (16)

5)Where $x^{(1)}(t + 1)$ is the predicted value of the accumulated value, and it is reduced to the

original data by one reduction:

$$x^{(0)}(t+1) = x^{(1)}(t+1) - x^{(1)}(t) = -a\left(x^{(0)}(1) - \frac{b}{a}\right)e^{-at} \qquad (t=1,2,3\ldots n) \qquad (17)$$

The RBF neural network is a three-layer forward neural network with a radial basis function as a hidden layer activation (nuclear) function, including input layer, hidden layer and output layer. It has strong approximation, classification and learning speed, and topology. The structure is shown below
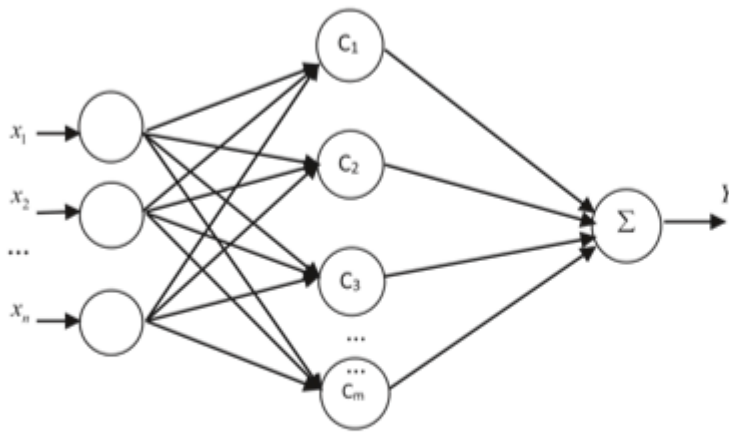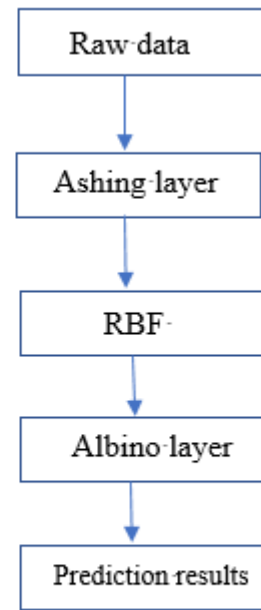

Fig4. RBF structure

Fig5.grey system-RBFsystem

Where $X=(x_1, x_2, \ldots x_n)$ is the input vector, $C=(C_1, C_2, \ldots C_M)$ is the hidden layer, passing the Gaussian function $c_i(x) = \exp\left(\frac{\|x-c_i\|}{2\delta_i}\right)$ Implementing a nonlinear mapping of the input layer to the hidden layer, where c_i is the center of the i-th basis function, $\|x-c_i\|$ is the norm of the vector $x-c_i$, ie the distance between x and c_i, δ_i is the first i perceptual variables, Y is the output vector, is the linear mapping of the hidden layer c, $Y = \sum_{j=1}^{m} w_j\, c_j, w_j\,(j=1,2\ldots m)$ is the jth The weight of the node to the output layer.

5.3.2 Model Establishment

- Step1: Ash the input data to eliminate the randomness of the data.
- Step2: RBF neural network
- Step3: Add a white layer after the output layer to restore the output data.
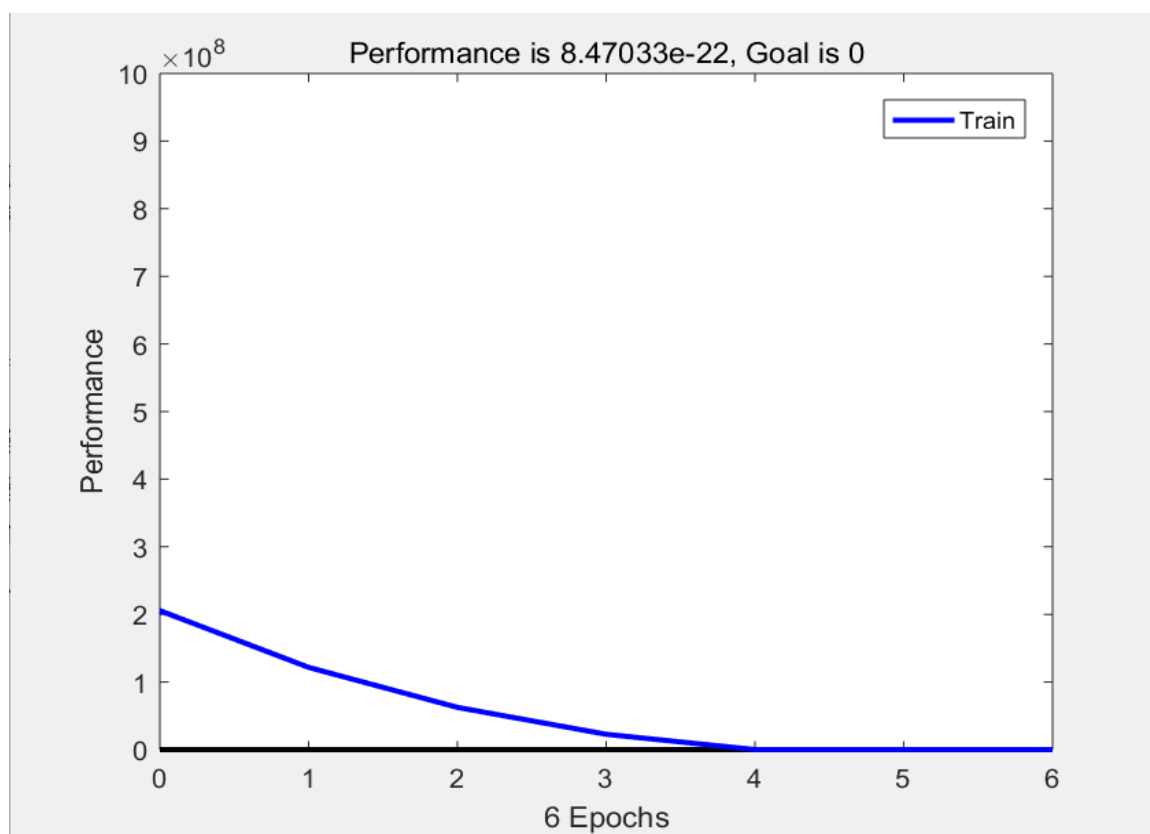
5.3.3 Train Results

Fig6. Training result

5.3.4 Analysis of the Result

Combining the above three models, we propose the following four strategies to combat the opioid crisis, and illustrate the effectiveness of the strategy in combination with the model:

1) Increase the management and supervision of opioids through state legislation or national legislation, and reduce the chances of people getting in contact with or obtaining opioid addictive drugs. Combined with the first model, it was verified that the case incidence decreased as λ decreased.

2)Increase employment opportunities for low-income people and reduce the gap between the rich and the poor.

3)Communities and schools promote publicity on the harm of opioid abuse.

4)Open office-run schools to increase the proportion of educated residents in poor communities. Combined with the second model, when the proportion of education and education of residents rises, the rate of case-discovery within the state has a downward trend.

We conducted correlation analysis on the characteristic parameters corresponding to several strategies, and extracted the "law on the management and supervision of opioids" with the strongest correlation with the case incidence rate, corresponding to the σ parameter in model one. Assuming that the propagation rate λ is consistent, when σ>λ, the strategy achieves the expected effect of inhibiting drug transmission, and when σ<λ, the strategy cannot achieve the desired effect.

6. Evaluation and Promotion of Model

6.1 Strength and Weakness

6.1.1 Strength

①The differential equation model and the RBF neural network model can be used to accurately predict the total number of patients and the infection rate.

②According to the differential equation model, the characteristics of Aka drug transmission can be well explained, and according to the critical value found, the spread of Aka drugs can be effectively prevented.

③We can find the socioeconomic internal factors that promote or inhibit the spread of Aka drugs based on the results of R-type cluster analysis and correlation analysis.

6.1.2 Weakness:

①The data in the paper is limited, only the data from 2010 to 2017, so the model built can not completely avoid the contingency of the data.

②The improved differential equation model was established because the data was not sufficient enough to solve the equation.

7. Conclusions

7.1 Conclusions of the problem

◆ The synthetic opioid propagation process satisfies the differential equation model with λ (daily contact rate) and μ (daily cure rate) as parameters. When λ (daily contact rate) is greater than μ (day cure rate), "opioid crisis" is exacerbated.

◆ Among the many socio-economic factors in the state, the degree of education and the place of origin have a greater correlation with the incidence of opioid-based cases. The higher the level of education, the lower the incidence of cases.

◆ There is a certain correlation between the incidence of opioids in neighboring states, indicating that interstate transportation is an important factor in promoting drug circulation, and proposes a strategy to deal with "opioid crisis" in terms of education level and social gap between the rich and the poor.

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January 29, 2019

Dr. Decision Maker C

From this year's competition C, we learned a hot spot: the United States is facing a serious crisis of Aka drugs. This situation has had a huge impact on the social and economic order of the United States. Therefore, based on the similarity of the characteristics of the spread of Aka drugs and the characteristics of the spread of infectious diseases, we have established a differential equation model based on the infectious disease model. We further conducted some analysis on the relationship between the spread of Aka drugs and the indicators of socioeconomic analysis in the United States.

However, due to the large number of analytical indicators, there is a strong correlation between the indicators. We first perform R-type cluster analysis on all Ohia indicators, and divide all the analysis indicators into five categories, and select one representative analysis index from each of the five categories. Through the analysis of the transmission rate of Aka drugs and the five analytical indicators and correlation analysis, it is concluded that there is a strong correlation between the two. For further analysis, we improved the previously established differential equation and modified the daily infection rate based on the definition of the infectious disease model from a previously assumed constant to a variable with respect to time variation, thus establishing a more consistent Aka. An improved differential equation model for the actual propagation of drugs. In the third part, we try to simulate the interference of the national policy intervention on this model, but because of the given data, we have established a gray-RBF neural network prediction model to test the differential equation model.

Before the game, we prepared two sets of task assignments: Plan A data modeling class completed by A major modeling, I was responsible for writing and assisted programming, B was responsible for writing; Plan B mechanism modeling class was responsible for modeling assistance. Writing, Zhen A is writing assisted modeling. Why is this division of labor? In fact, due to the reason of A major and multiple competitions, it has rich experience in data mining and operations research. On the other hand, I have some achievements in the physics academic competition and the mechanics competition. The mechanism modeling ability is better. It is easier to deal with similar issues such as the national race, moon landing, shadow positioning, etc. The plan is preventive.

After four days of hard work, I completed 21 pages of text writing in 4 days, and the workload was huge. The establishment of the third-level model also allowed us to work without rest during the last 48 hours (T.T, please pay attention to your body while struggling with youth). Of course, the ability to complete a paper on time is largely due to multi-line writing.

Wish our proposal can inspire you in pursuit of a a society without drugs. We are looking forward to hearing from you. Yours sincerely, A team of modelers who are enthusiastic about environmental preservation

Yours Sincerely,

Team # 1911245