Soybean Yield Forecast Application Based on HOPFIELD ANN Model

Lishu Wang[1], Guoqiang Qi[1], Qiang Fu[2], Yan Liu[3]

1. School of Engineering, Northeast Agriculture University, Harbin, Heilongjiang 150030, China
2. School of Water Conservancy & Civil Engineering, Northeast Agriculture University, Harbin, Heilongjiang 150030, China
3. Harbin Tie Ling Primary School, Harbin, Heilongjiang 150001, China

Abstract: This article establishes the estimate's mathematics model of the soybean's yield, using the artificial nerve network's knowledge, and by the model we can increase accuracy of the Soybean Yield Forecast. [The Journal of American Science. 2006;2(3):85-89].

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1. Foreword

By setting up simulation model , we can get some relevant conclusions and realize predict function in order to assist people making decision [1]. In general situation, it is very difficult to set up relative and accurate mathematics model reflect objective systems, it is even impossible sometimes, but there are certain relations between various kinds of factors[3] [4]. If we can find the mathematics model which reflect the

If $Q = \left| y - \hat{y} \right| = \left| \hat{f}(x_1, x_2, \cdots x_n) - f(x_1, x_2 \cdots x_n) \right| \to 0$

Then we think that the model $y = f(x_1, x_2, \cdots x_n)$ is successful, and we can use it in Forecasting. In numerous artificial nerve network models, Hopfield nerve network is widely used, this text apply this model to soybean predict field, In order to improve utilization ratio of fertilizer, impel the soybean excellent quality, high yield , reach the unity of economy, the ecology and social benefit.

realistic input and output system, it has very important significance in Yield Forecasting.

Assume the system mathematics model as follow：

$$\hat{y} = \hat{f}(x_1, x_{2,} \cdots x_n)$$

Set up the mathematics model:

$$y = f(x_1, x_2, \cdots x_n)$$

2. Brief introduction of the Hopfield Nerve network

Hopfield Nerve network Mathematics model as follow[2]:

$$\begin{cases} C\dfrac{du_i}{dt} = -\dfrac{u_i}{R} + I_i + \sum_{j=1}^{N} T_{ij} V_j \\ V_i = g(u_i) \quad i = 1,2 \cdots, N \end{cases}$$

T_{ij} —join Proportion Number value between neuron member i and j

$g(u_i)$ — monotony Increase progressively Continuous function, and $T_{ij} = T_{ji}$

u_i—Inputting value of i, V_i—Exporting value of i.

Simplify models.

$$\begin{cases} \dfrac{du_i}{dt} = \sum_{j=1}^{N} T_{ij} V_j + I_i \\ V_i = g(u_i) \quad i = 1,2\cdots,N \end{cases}$$

define systematical energy function is:

$$E = -\frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} T_{ij}V_iV_j - \sum_{i=1}^{N} V_i I_i$$

We can prove dE/dt≤0, only when dVi/dt=0 that dE/dt=0 (i=1,2,⋯,N), that is to say that the system's Stable and Balanced point is extreme small point of Energy Function E, so the operation course on this network is a course seeking excellent the extreme small point in fact. Goal function is the energy function of this network system[5].

3. Setting-up The predicted and Simulation model of soybean's Yield

As mentioned above, it is the more difficult thing to set up its intact prediction mathematics model for the realistic system. So is the relation of Yield with the balance of soybean applies fertilizer, because six indexes which can influence the balance of the soybean to apply fertilizer. As there is a relation between a great deal of factors (the independent variable) and the yield of soybean. Set mathematics model systematically as:

$$\hat{y} = \hat{f}(x_1, x_{2,} \cdots x_n)$$

x_1 , $x_2 \ldots x_n$ ——Influence factors of the output of soybean，Such as：Soil organic matter、The ammonium form nitrogen、The nitre form nitrogen、Quick-acting phosphorus、Quick-acting potassium、pH value etc，which can instruct the balance of soybean to apply fertilizer。

We can make use of following model to fit, and get[6]

$$y = \beta_0 + \sum_{j=1}^{N}\beta_j x_j + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}x_ix_j + \sum_{j=1}^{N}\sum_{i\le j}\sum_{k\le i}\beta_{ijk}x_ix_jx_k + \cdots$$

In above formula, β_0, β_j, β_{ij}, β_{ijk},⋯, parameters to be estimate; Under normal conditions, it is enough to use two steps to fit, after every parameter appeared in the estimation that we can predicted the function.

Assume P is the sample number, $\hat{y}_p\,(p = 1,2\cdots,p)$ is variable, $x_{pj}\,(\mathrm{j} = 1,2,\cdots,\mathrm{N})$ is number

$$\mathrm{Q} = \frac{1}{2}\sum_{\mathrm{p}=1}^{\mathrm{P}}(\mathrm{y_p} - \hat{\mathrm{y}}_\mathrm{p})^2$$ reach extremely small.

y_p ——The output of the fitting model；Define the energy function :

$$E = \mathrm{Q} = \frac{1}{2}\sum_{\mathrm{p}=1}^{\mathrm{P}}(\mathrm{y_p} - \hat{\mathrm{y}}_\mathrm{p})^2$$
$$= \frac{1}{2}\sum_{p=1}^{p}(\beta_0 + \sum_{j=1}^{N}\beta_j x_{pj} + \sum_{j=1}^{n}\sum_{i\le j}\beta_{ij}x_{pi}x_{pj} + \sum_{j=1}^{N}\sum_{i\le j}\sum_{k\le i}\beta_{ijk}x_{pi}x_{pj}x_{pk} + \cdots - \hat{y}_p)^2$$

take two steps, and get

$$E = \frac{1}{2}\sum_{p=1}^{p}(\beta_0 + \sum_{j=1}^{N}\beta_j x_{pj} + \sum_{j=1}^{n}\sum_{i\le j}\beta_{ij}x_{pi}x_{pj} - \hat{y}_p)^2$$

so we know

$$\frac{\partial E}{\partial \beta_0} = \sum_{p=1}^{p}(\beta_0 + \sum_{j=1}^{N}\beta_j x_{pj} + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}x_{pi}x_{pj} - \hat{y}_p)$$

$$= P\beta_0 + \sum_{j=1}^{N}\beta_j(\sum_{p=1}^{P}x_{pj}) + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}\cdot(\sum_{P=1}^{p}x_{pi}x_{pj}) - \sum_{p=1}^{P}\hat{y}_p$$

$$\frac{\partial E}{\partial \beta_j} = \sum_{p=1}^{p}(\beta_0 + \sum_{j=1}^{N}\beta_j x_{pj} + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}x_{pi}x_{pj} - \hat{y}_p)x_{pj}$$

$$= \beta_0\sum_{p=1}^{P}x_{pj} + \sum_{j=1}^{N}\beta_j(\sum_{p=1}^{P}x^2{}_{pj}) + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}\cdot(\sum_{P=1}^{p}x_{pi}x^2{}_{pj}) - \sum_{p=1}^{P}\hat{y}_p x_{pj}$$

$$\frac{\partial E}{\partial \beta_{ij}} = \sum_{p=1}^{p}(\beta_0 + \sum_{j=1}^{N}\beta_j x_{pj} + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}x_{pi}x_{pj} - \hat{y}_p)x_{pj}(x_{pi}x_{pj})$$

$$= \beta_0\sum_{p=1}^{P}x_{pi}x_{pj} + \sum_{j=1}^{N}\beta_j(\sum_{p=1}^{P}x_{pi}x^2{}_{pj}) + \sum_{j=1}^{N}\sum_{i\le j}\beta_{ij}\cdot(\sum_{P=1}^{p}x^2{}_{pi}x^2{}_{pj}) - \sum_{p=1}^{P}\hat{y}_p x_{pi}x_{pj}$$

$\frac{d\beta_0}{dt} = -\frac{\partial E}{\partial \beta_0}, \frac{d\beta_j}{dt} = -\frac{\partial E}{\partial \beta_j}, \frac{d\beta_{ij}}{dt} = \frac{\partial E}{\partial \beta_{ij}}$, and order $g(x) = \begin{cases} x & x \ge 0 \\ 0 & x < 0 \end{cases}$

Hopfield nerve network necessary parameters are：

$$I_0 = \sum_{p=1}^{P}\hat{y}_p, I_j = \sum_{p=1}^{P}\hat{y}_p x_{pj}\,,\; I_{ij} = \sum_{p=1}^{P}\hat{y}_p x_{pi}x_{pj}\,,\; T_{00} = -P\,,\; T_{ij} = -\sum_{p=1}^{P}x_{pj}^2\,,\; T_{ij\cdot ij} = -\sum_{p=1}^{P}x_{pj}^2 x_{pj}^2$$

$$T_{0.j} = T_{j.0} = -\sum_{p=1}^{P}x_{pj}\,,\; T_{0.ij} = T_{ij.0} = -\sum_{p=1}^{P}x_{pj}x_{pi}\,,\; T_{j.ij} = T_{ij.j} = -\sum_{p=1}^{P}x_{pi}x_{pj}^2$$

To the high-order situation, we can get:

$$I_0 = \sum_{p=1}^{P}\hat{y}_p, I_{ij\cdots k} = \sum_{p=1}^{P}(\hat{y}_p x_{pi}x_{pj}\cdots x_{pk}), T_{00} = -P, T_{(ij\cdots k)\bullet(ij\cdots k)} = -\sum_{p=1}^{P}(x_{pi}^2 x_{pj}^2\cdots x_{pk}^2)$$

$$T_{0\cdot(ij\cdots k)} = T_{(ij\cdots k)\cdot 0} = -\sum_{p=1}^{P}(x_{pi}x_{pk}\cdots x_{pk}), T_{i\cdot(ij\cdots k)} = T_{(ij\cdots k)\cdot i} = -\sum_{p=1}^{P}(x^2{}_{pi}x_{pk}\cdots x_{pk})$$

Among them, p=1,2,⋯,P；j=1,2,⋯N; k≤⋯≤i≤j.

Utilize above-mentioned parameter values we can construct soybean apply fertilizer Hopfield nerve network which predicts yield conveniently, This network reach a stable equilibrium of states, exports value which fit the parameter values of curved surface are what we need estimate promptly. The state of stable equilibrium at this moment, is the state of the soybean of relatively high yield[7] [8].

4. The experiment of the computer

Choose a group of data as Form 1 shows are single factors, adopt 1 step to fit the relations of *yi* and *xi*, *Yi* is the average yield of soybean, *xi* is the amount of application of nitrogen, i.e $y = a + bx$, and i =1,2, …., 12, use ahead derived result, we can construct necessary every parameter respectively for network nerve Hopfield:

$$T_{aa} = -12, T_{bb} = -390, T_{ab} = T_{ba} = -78, I_a = 2074.3, I_b = 14242.8$$

This system dynamic equation is:

$$\begin{cases} \dfrac{du_a}{dt} = -12u_a - 78u_b + 2074.3 \\ \dfrac{du_b}{dt} = -78u_a - 390u_b + 14242.8 \\ a = u_a \\ b = u_b \end{cases}$$

use Euler method to solve, take initial value u_a=0, u_b=0, step h=1.0E-7, Change and take the place of a=2.5822887, b=5.0504757, to accelerate simulation operation disappear speed by, we change step h=1.0E-6, in the end we get steady result

a=138.26, b=5.322

So, the fitting equation received is: y=138.26+5.322x

Form 1. Experimental data

i	1	2	3	4	5	6	7	8	9	10	11	12
x_i	1	2	3	4	5	6	7	8	9	10	11	12
Y_i	143.5	148.9	154.2	159.5	164.8	170.2	175.5	180.8	186.2	191.5	196.8	202.1

Utilize least square method, Get equation:

y=139.26+5.822x

Form 2: It is these two kinds of methods that export the comparison of the result.

Using least square method get *y*=139.26+5.822x. Form 2 is export results to compare.

Form 2. Export results to compare

The method	Absolute error Total	Average absolute error	Square Error	Standard deviation error
Nerve network	2.853	0.319	0.258	0.628
Least square method	3.05	0.33	0.228	0.567

5. **Conclusion**

This paper has put forward a model to predict the yields of soybean with Hopfield nerve network raise the predicting accuracies of soybean yield, improve utilization ratio of fertilizer also, achieve the goal of increasing production[9]。

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Correspondence to:

Lishu Wang, Guoqiang Qi, Qiang Fu, Yan Liu
School of Engineering
Northeast Agriculture University
Harbin, Heilongjiang 150030, China
Telephone: 01186-451-89971785
Email: wanglishu@neau.edu.cn

References

1. Ma Feng-shi. Probability statistics. Higher education Publishing house, 1989.
2. Jiao Li-cheng. The network system theory of nerve. The electronic University of Science and Technology Publishing house, 1990.
3. Eugene Chamik, Introduction to Artificial Intelligence, Addison-Wesley Publishing Company Inc. 1985:12-44.
4. Subrahmanian. S. Jajodia. Data base system of multimedia. 1998.8：35-46.
5. Deck S H , Mokow C T, Heinemann P H, et al. Sommer Com parison of a neural network and traditional classifier for machine vision inspection [J]. Applied Engineering in Agriculture, 1995, 11.
6. Zhang Xin, Cai Wei-guang utilize ANN realize forecast modeling. 1997.
7. Haykin S. Neural Networks: A Comprehensive Foundation[M]. Macmillan College Publishing Company, Inc, New York, NY, U SA. 1994.
8. Zhang Ning, Zheng Junli. An Artificial Neural-Based A/D Converter Using Asymmetric Hopfield Network ICCAS-91. Shenzhen, China. 1999.
9. Muller B, Reinhardt J. Neural Networks An Introduction. Spinger-Verlag, 1990.