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Ecological Environment Monitoring System of Litopenaeus Vannamei Farming Based on Neural Network

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Abstract: One ecological environment monitoring system of Litopenaeus vannamei farming has been developed in order to protect and regulate the ecological environment of Litopenaeus vannamei farming, halt and reverses the situations in the ecological environment deterioration of Litopenaeus vannamei farming and the little farming success rate. The early warning information of ecological environment degradation is automatically generated by means of the generalized polynomial neural network so as to prompt the user to take effective measures to improve farming ecological environment in a timely manner and effectively increase the success rate of shrimp farming. *Copyright © 2013 IFSA.*

Keywords: Litopenaeus vannamei, Ecological environment, Early warning, Neural network.

1. Introduction

Litopenaeus vannamei is of many advantages, such as high temperature resistance, miscellaneous diet, low dietary protein requirements, euryhaline, short growth cycle, big individual, high-yield, strong disease resistance, delicious meat and easy to transport [1]. Its processing meat rate is up to 67 %, and it is an excellent desalination breeding variety and has become a major shrimp species cultured in southern China [2, 3]. Its appropriate ecological environment factors are as follows [4-6]:

Optimum water temperature: 22~32 °C;
Adaptive salinity: 5 % ~ 45 % ;
PH value range:7.5 ~ 8.6 ;
Dissolved oxygen: > 2 mg/L ;
Chemical oxygen demand: 5 ~ 30 mg/L ;
Transparency: 0.2 ~ 0.9 m ;
Ideal water colors: dark brown and yellowish green;
Phosphate content: 0.1 ~ 0.3 mg/L ;
Silicate content: 0.2 mg/L ;
Ammonia nitrogen content: < 0.3 mg/L.

But the aquaculture pond is both feeding pond and metabolic pond of shrimp as well as the oxidation decomposition pond of organic matter for shrimp aquaculture ways, so there exists a few problems, such as weak aquaculture pond ecosystem and low self-purification capacity [7] so as to worsen the aquaculture ecological environment, even trigger shrimp disease occurrence, and impede the normal growth of farmed shrimp to seriously hamper the improvement of feeding efficiency.

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The neural network theory [8-10] is applied to the dynamic change tracking and forecasting of ecological environment factors of Litopenaeus vannamei farming in order to solve the above problems to build the predictive models of ecological environment factors and set up the early warning mechanism of ecological environment factors degradation to achieve the ecological environment real-time monitoring of Litopenaeus vannamei farming.

2. Research Methods

The ecological environment key factors to impact Litopenaeus vannamei farming were screened out by reference to the ecosystem research achievements of Litopenaeus vannamei farming. The polynomial neural network was applied to the overall quality evaluation of shrimp farming ecological environment to build the forecasting models of shrimp farming ecological environment factors and quantificationally work out the change results of aquaculture environment factors to accurately track and forecast the dynamic change trends of ecological environment of Litopenaeus vannamei farming. Thus, farmers can visually understand the changes in the environment of Litopenaeus vannamei farming; farmers are prompted to timely take effective measures and adjust ecological indicators to help to improve shrimp production against sudden ecological indicators degradation so as to effectively improve the success rate of shrimp farming.

A dynamic ecological environment monitoring system of Litopenaeus vannamei farming was developed by combining the theory and methods of neural networks and aquaculture, and it has friendly interface and is easy to operate. The technical route flow chart is shown in Fig. 1.

3. System Development Environments

CPU: configuration of above Pentium III; Memory: more than 512 M; Monitor resolution: above 1024×768.

Operating system: higher than Windows Server 2003; Browser: higher than IE 6.0; Database: higher than Sql Server 2005; higher than Net Framework 2.0; higher than IIS 6.0.

Programming language: HTML/javascript/css/ T-SQL/C#.

4. System Design

4.1. System Function Module

The system functions are shown in Fig. 2, including industry dynamic; historical monitoring data and analysis; disaster history; early warning information of disaster; shrimp picture library; shrimp farming knowledge base; introduction to neural networks and system back-stage management.

4.2. Database Design

Entity E-R model was built as a basis for completing the table structure design of system through needs analysis, and the system possessed a total of nine data tables, where Table 1 shows the table structure of warning information:

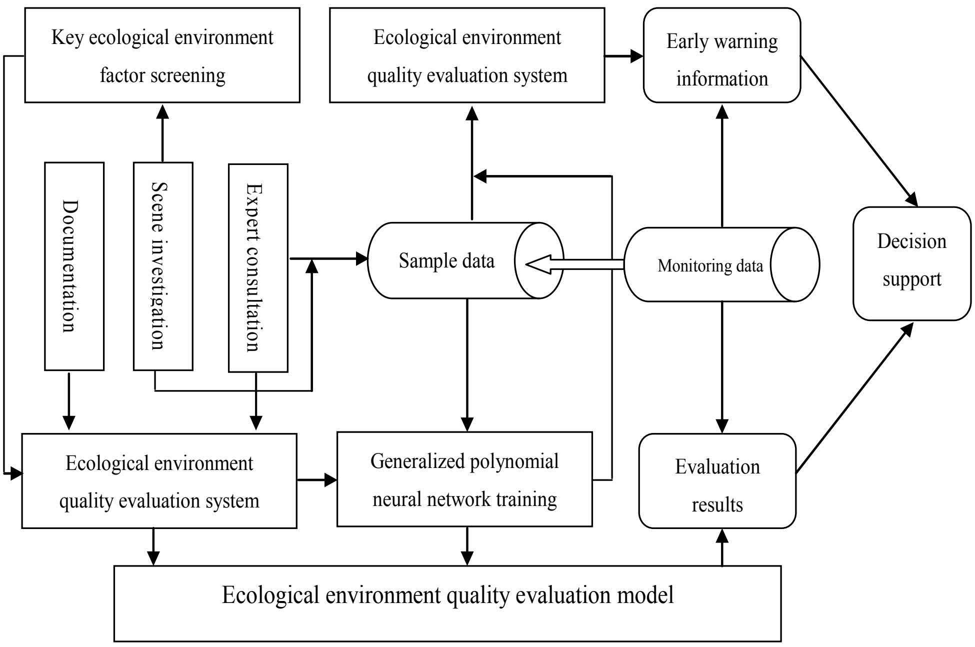

Fig. 1. Technical route flow chart.

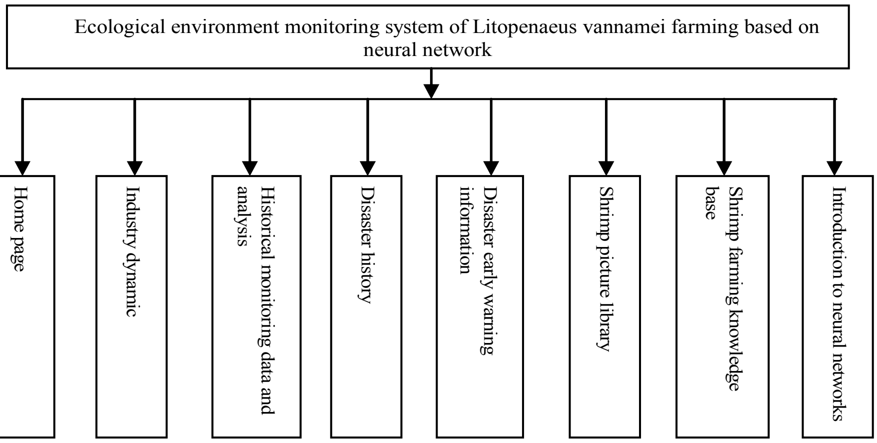

Fig. 2. Main interface of system.

Table 1. Warning (warning information).

No.	Name	Data Type	Length	Deci-mals	Identifi-cation	Primary Key	Allowed Empty	Default	Introductions
1.	id	int	4	0	Yes	Yes	No		
2.	Data Item Id	int	4	0			Yes		Generated warning information data item id (Monitoring Data_id)
3.	Title	nvarchar	100	0			Yes		Information title
4.	Warning Message	nvarchar	400	0			Yes		Warning information content
5.	Create_User	nvarchar	50	0			Yes		
6.	Create_Time	datetime	8	3			Yes		
7.	Update_User	nvarchar	50	0			Yes		
8.	Update_Time	datetime	8	3			Yes		
9.	Record_Sta	int	4	0			Yes	((0))	Record status (0: effective, 1: invalid)

5. Implementing the Monitoring Functions of Ecological Environment

Improving the success rate of shrimp farming is system engineering and needs a series of technical research and development and integration. The effective early warning of ecological environment deterioration of shrimp farming is the most important part of this R & D project, and the system uses the prediction model of generalized polynomial neural network to achieve the early warning function of ecological environment factor changes of Litopenaeus vannamei farming.

5.1. Generalized Polynomial Model of Neural Network and Forecasting Principles

The related literature established a generalized polynomial model of neural network (Fig. 3) [8].

Network output is:

$$y = \sum_{i=1}^{n} w_i p_i(x_1, x_2, \cdots, x_m), \tag{1}$$

Sample set is set up as $\{((x_1(t), x_2(t), ..., x_m(t), y(t)), t = 1, 2, \cdots, l$ (where the sampling value is $y(t)$, and the number of samples is l) for m element objective function $f(x_1, x_2, ..., x_m)$. The output vectors of all samples in sample set and neural network weight vector are ordered as

$$\gamma = \begin{bmatrix} y_1 & y_2 & \cdots & y_d \end{bmatrix}^T \in R^l$$

and

$$w = \begin{bmatrix} w_1 & w_2 & \cdots & w_n \end{bmatrix}^T \in R^n,$$

respectively. The excitation function of hidden layer neuron is set up as $p_i(x_1, x_2, \cdots, x_m)$. The excitation response of the i-th hidden neuron to the t-th sample is $q_i^{(t)} = p_i(x_1, x_2, \cdots, x_m)$ where

$t = 1, 2, \cdots, l; i = 1, 2, \cdots, n$ The excitation-response vector of hidden layer to the t-th sample is $q^{(t)} = [q_1^{(t)} \quad q_2^{(t)} \quad \ldots \quad q_n^{(t)}]^T \in R^n$. Then, the excitation response matrix of hidden layer to all samples is

$$Q = \begin{bmatrix} q_1^{(1)} & q_2^{(1)} & \cdots & q_n^{(1)} \\ q_1^{(2)} & q_2^{(2)} & \cdots & q_n^{(2)} \\ \vdots & \vdots & \ddots & \vdots \\ q_1^{(l)} & q_2^{(l)} & \cdots & q_n^{(l)} \end{bmatrix} \in R^{l \times n},$$

and thus, the optimum weight of neural network can be obtained:

$$w = Q^+ \gamma, \tag{2}$$

The ecological environment factor changes of Litopenaeus vannamei farming are set up as a nonlinear system:

$$y(k) = F[y(k-1), \cdots, y(k-n)], \tag{3}$$

without loss of generality, after the simulation models of ecological environment factors of Litopenaeus vannamei farming were built using the above method. Where, $y(k)$ $(k = 2, 3 \cdots, N, n << N)$ is the given sample collection data, and $F(\bullet)$ is the unknown nonlinear dynamic function of Litopenaeus-vannamei farming ecological environment. Thus, the forecasting principles [10] of generalized polynomial neural network are shown in Fig. 4.

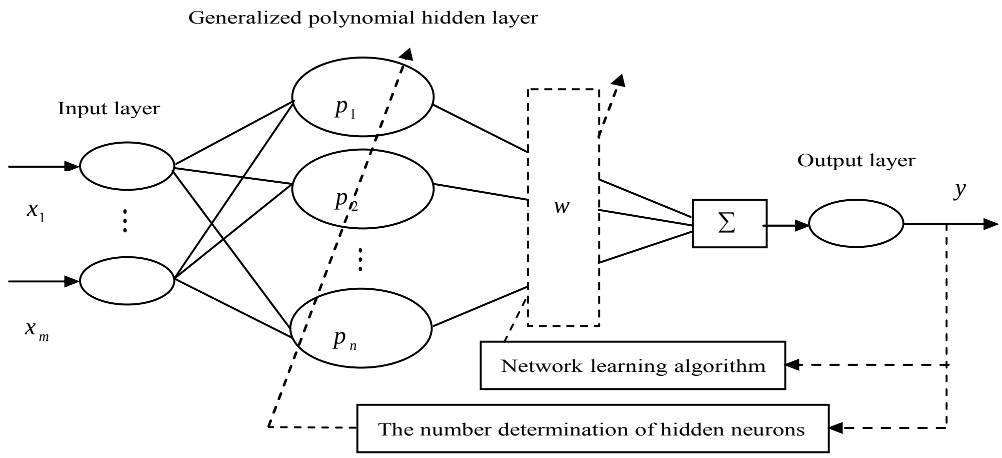

Fig. 3. Generalized polynomial model of neural network.

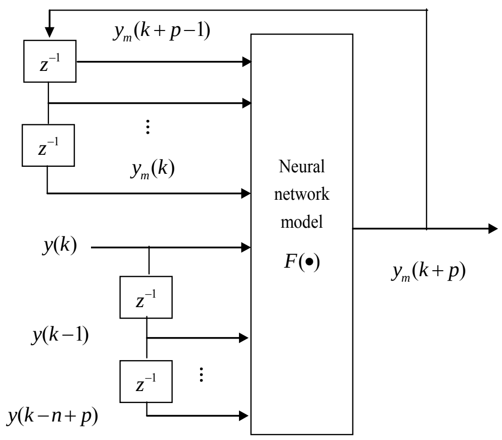

Fig. 4. Drawing of neural network forecasting principles.

The implementation process is as follows: First, the measured data of the dynamic changes in the ecological environment factors is collected in Litopenaeus vannamei farming process. Then, the data is as the training samples of generalized polynomial neural network shown in Fig. 3, and the trained neural network is the simulation model of ecological environment factors of Litopenaeus vannamei farming. Again then, the dynamic change prediction model of ecological environment factors of Litopenaeus vannamei farming was established according to Fig. 4 to generate real-time alarm information.

5.2. Pond Environmental Monitoring

The pond information list (see Fig. 5) is entered into by clicking the "pond environmental monitoring" link of back-stage management so as to perform the operations to add, modify, delete or query pond as well as view or manage monitoring data corresponding to each pond.

5.3. Monitoring Factors

The monitoring factor management interface is entered into by clicking the "monitoring factor management" link on the left of back-stage management to look the monitoring factor list up (see Fig. 6).

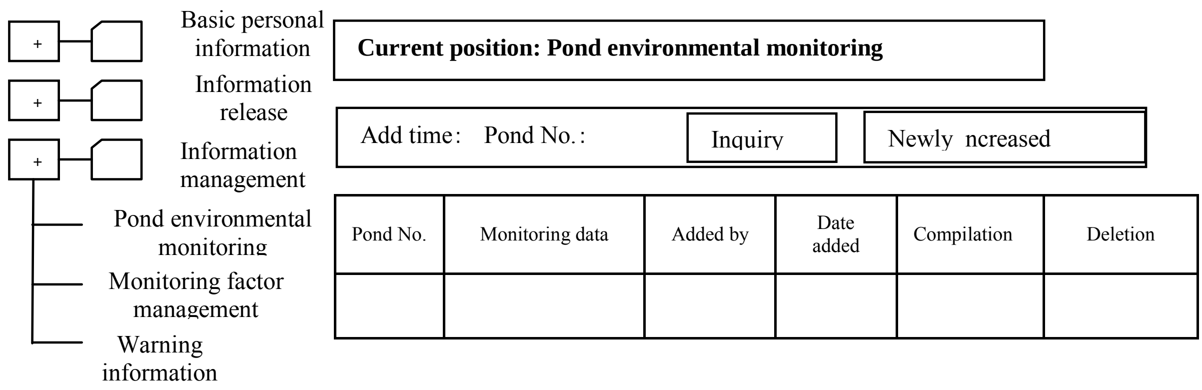

Fig. 5. Pond information

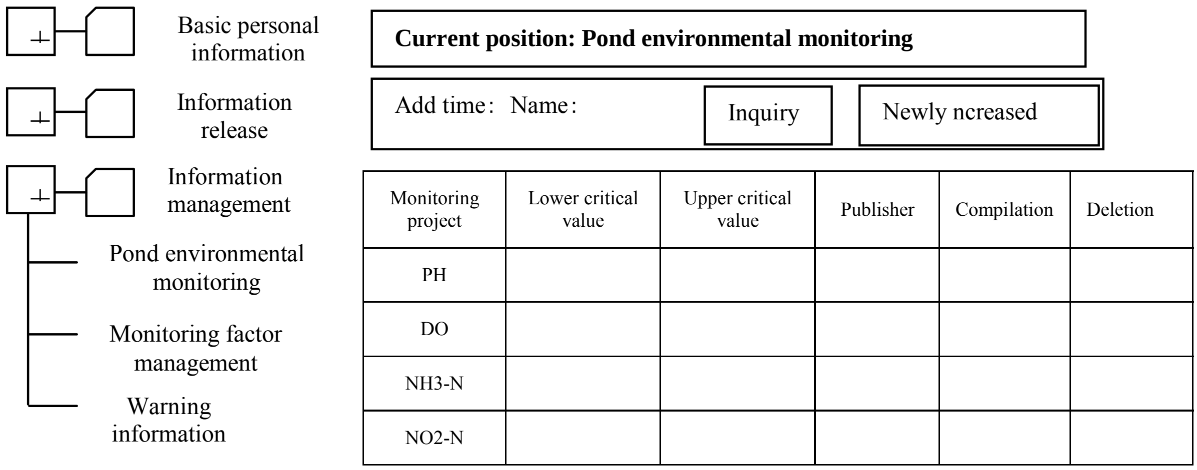

Fig. 6. Monitoring factor list.

5.4. Historical Monitoring Data and Neural Network Prediction

The "historical monitoring data and analysis" in the navigation bar is clicked to access this column page. Query date, pond number and item are input in the query conditions (see Fig. 7), and then the query results are displayed.

The interface of warning information list is entered into by clicking the "warning information" link on the left of back-stage management to generate warning information after the deterioration of each ecological environment factor. For example: Fig. 8 is the alarm content generated by system.

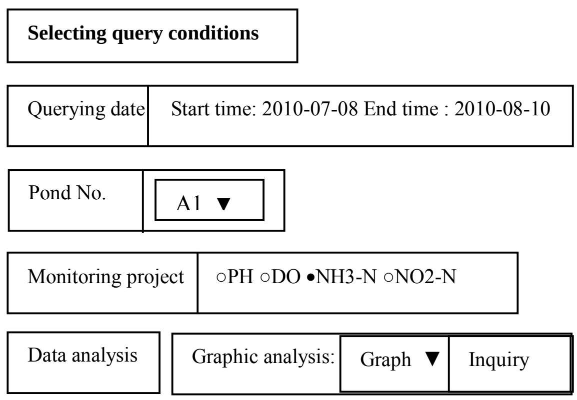

Fig. 7. Historical monitoring query.

The NO2-N monitoring value of A1 pond is too high.

Alarm content	The upper limiting standard value of monitoring item (NO2-N) is 0.15. The current monitoring value of A1 pond is 2.420, so it is too high. Suggested solutions: □ Cleaning up pond silt □ Oxygenation □ Adjusting PH value Monitoring reporter: admin Reporting time: 2010-8-7 0:00:00

Fig. 8. Warning information.

6. Conclusions

The system interface is friendly and easy to operate so that farmers can visually understand the changes in the environment of Litopenaeus vannamei farming. The system can prompt the user to timely take effective measures and adjust the ecological indicators to help to improve shrimp production for deterioration of ecological indicators so as to effectively improve the success rate of shrimp farming. The popularization and application of research achievements is meaningful to enhance the reasonable farming and scientific management of Litopenaeus vannamei.

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