Catastrophe Prediction of Cnaphalocrosis Medinalis Based on Fuzzy Reasoning

Fei Yu[1,2,3], Yue Shen[1], Guangxue Yue[2,3], Ronghui Wu[3], and Cheng Xu[3]

[1] School of Computer & Information Engineering, Hunan Agricultural University, Changsha 410128, China
{yufei,shenyue}@hunau.edu.cn
[2] State Key Laboratory of Information Security, Graduate School of Chinese Academy of Sciences, Beijing, 100049, China
yufei@hunau.edu.cn
[3] Provincial Key Lab of Image Processing & Imagecom Communication , Nanjing University of Pos & Telecommunications, Nanjing , 210003, China
hunanyufei@126.com

Abstract. The pest catastrophe prediction in ecology catastrophe is one of important part in expert system of intelligence agriculture and also the guarantee for preventing and controlling the pest catastrophe occurrence efficiently. The paper introduces the basic principles and methods of current catastrophe prediction in ecology catastrophe. According to modeling for the dynamic process of population, up-grown and amount of spawn, the paper finds out the trigger point and critical value inducing the pest catastrophe and implements the catastrophe prediction of Cnaphalocrosis Medinalis, which take measures before catastrophe to prevent big population coming into being.

1 Introduction

Some mainly pests in crops have regionally migratory, eruptive and destructive characteristics[1][2]. It is very difficult to forecast for the paroxysm in migratory pests. Since “six. five”, national science committee have tackled the key problems in forecast of pests, which made the forecast rate has already reached 80 percent. But the remainder other 20 percent which cannot predict by normal methods are just the eruptive increase of pest populations which need forecast precisely. The outbursts of beet webworms in 1980s, cotton bollworm in 1992, rice louses in 1997 and 1991 etc, made people cannot prevent in advance and met the emergency passively, had the disastrous losing.

2 Catastrophe Prediction Module of Cnaphalocrosis Medinalis

Though there are the outside random factors, with the knowledge of pest catastrophe occurrence regular and outside factors physical process deepened little by little, it is possible to divide a part of outside random factors to make them predictable. Since

Y. Shi et al. (Eds.): ICCS 2007, Part III, LNCS 4489, pp. 109–112, 2007.

the un-forecasting proportion decided by outside random factor is more and more little, it improve the forecasting right ratio to the long-term prediction. In essence, the possibility of long-term prediction depends on inherence random of system. The continuity in pest catastrophe occurrence process, dispersion of pest catastrophe occurrence data, un-dynamic evolvement characteristics in pest catastrophe occurrence system result in the complexity of pest catastrophe occurrence system. If the initial conditions or system parameters have little difference, the future state of pest catastrophe occurrence system will be different in essence. However, just uttermost sensitive to initial conditions, the pest catastrophe occurrence represents stability to abnormal. In principle, both the chaos behavior to dissipative nonlinear system and chaos behavior to HARMILTON nonlinear system all can have statistic description by the fix distributed function, which proves the pest catastrophe prediction is possible[3].

3 Implemention of Inference Machine of Catastrophe Prediction

The fuzzy rules of the Oth-order Sugeno model can be expressed as follows[4]:

$$R_i : if \;\; x_1 \text{ is } A_1^i \text{ with } m_1^i \text{ and } x_2 \text{ is } A_2^i \text{ with } m_2^i \text{ and} \ldots x_n \text{ is } A_n^i \text{ with } m_n^i \text{ then } y_1 \text{ is } B_1^i \text{ and} \ldots \; y_q \text{ is } B_q^i \tag{1}$$

3.1 Automatic Evolution of Fuzzy Rule Base

Through experts' knowledge and experience we can design fuzzy models, however, depending merely on such experience is quite inadequate especially when the target system we are modeling is unacquainted with many uncertainties. Therefore, researchers devoted themselves to designing the fuzzy models automatically based on training the acquired data. By utilizing EP to fuzzy modeling, we can simultaneously evolve the structure and the parameters of fuzzy rule bases for a given task[3]. States are the illuminations of the whole system state inferred by inference machine according to the information base and rules base. The paper defines states like OK, PRE_ATTACK, ATTACKING, ATTACKED.

In the original idea a standard deviation for mutation of the ith component zi, is obtained as a function of the fitness value of the mth individual $\theta(m)$ as follows:

$$z_i' = z_i + \sigma_i * N(0,1), \sigma = \sqrt{(\beta_i * \theta(m)) + \gamma_i} \tag{2}$$

In the design of an optimal fuzzy model, the fitness function usually used can be expressed as follows:

$$F = 1/E, E = \frac{1}{num}\left[\frac{1}{q}\sum_{p=1}^{q}\sum_{l=1}^{num}(y_{lp} - y_{lp}^*)^2\right] \tag{3}$$

3.2 Hybrid Learning Rule

Hybrid learning rule can be derived from J. S. Jang's research[3][6]on adaptive network. J. S. Jang observed that the output of a certain adaptive network is linear in some of the network parameters, which thereby can be identified by the least squares method. And then the combination of the gradient method and the LSE forms the so-called hybrid learning rule. For simplicity, assume that the adaptive network under consideration has only one output:

$$Output = F(X, S) \tag{4}$$

where X is the set of input variables, S is the set of parameters, and F is the whole function of which the adaptive network realizes. If there exits a function H such that the function $H \circ F$ is linear in some of the parameters of S, then these elements can he identified by the least squares method. More formally, if the parameter set can be decomposed into two sets:

$$S = S_1 \oplus S_2 \tag{5}$$

Remember to submit the psfig or epsf files and further style files and fonts you have used together with your source files.

such that $H \circ F$ is linear in the elements of S2,, then upon applying H to $Output = F(X, S)$, we have:

$$H(F) = H \circ F(BX, S) \tag{6}$$

4 The Implemention of Rules Base

According to the research results of Cnaphalocrosis Medinalis in recent years and based on the test information of pest test-station of plant prevention in HUNAN farm science academy, the paper described the inference by expert knowledge rules.

Table 1. Predict principle of occurrence period

Condition of Occurrence period	Condition of temperature	Result
the initial period of chrysalis	Larger or equal than 25 °C	initial period of imago after 10-13 days
the initial period of chrysalis	Less than 25°C	initial period of imago after 13-16 days
the fastigium period of chrysalis	Larger or equal than 25 °C	fastigium period of imago after 10-13 days
the fastigium period of chrysalis	Less than 25°C	fastigium period of imago after 13-16 days
the initial period of imago	Larger or equal than 25 °C	initial period of incubation after 6-7 days
the initial period of imago	Less than 25°C	initial period of incubation after 7-8 days
the fastigium period of imago	Larger or equal than 25 °C	fastigium period of incubation after 6-7 days
the fastigium period of imago	Less than 25°C	fastigium period of incubation after 7-8 days

The rules are divided to occurrence trend prediction, occurrence amount prediction, occurrence time prediction and loss rate prediction. The occurrence trend prediction is divided to the whole process of occurrence trend prediction, occurrence trend prediction of Cnaphalocrosis Medinalis in the metaphase of paddy growing and anaphase of paddy growing. The occurrence amount prediction is divided to spawn density and three ages grubs prediction. The occurrence time prediction is divided to the initial period of chrysalis, the fastigium period of chrysalis, the beginning of imago, the fastigium period of imago, the initial period of incubation, the fastigium period of incubation, the initial period of three ages grub, the fastigium period of three ages grub. The least and simplest rule table is as follows.

5 Conclusion

The biology technology and information technology are the mainly basic technologies in modern agriculture. With the geography information used widely in recent years, there are multi-subject intercrossing each other to develop. Compared to the traditional decision system of agriculture, the expert system of ecology catastrophe prediction proposed in paper is a single module, which has many deficiencies. The expert system is built based on the paddy plant information of HUNAN province and the experience of some experts. Our next research will be regarded as whether the system suits other area or not. Meanwhile, if the granularity of rules is too rough, it will effects the exactness of system, else add the overhead of communication between human and computer. How to find the most suitable granularity is the emphasis of next research.

References

1. Zhou Liyang,Zhang Xiaoxi:Prediction Expert System of Rice Leaf Roller in Jianghuai Rice Region. Journal of China Agricultural University,1996,19(3):44-50
2. Ju Baoping: Bio-disaster forecasting: challenges and strategies. Journal of Nanjing Agricultural University,2001,(4):41-45
3. Wang Sishui,Zhang Xiaoxi:Long-time Prediction of Rice Leaf Roller based on Neural Network. Journal of Plant Protect. 2000,27(4):313-316
4. H. V. Jagadish, A. O. Mendelzon, I. S. Mumik. : Managing conflicts between rules. Journal of Computer and System Science,1999, 58 (1):13-28
5. Huang Baohong, Xia Minghai. : Prediction of Rice Leaf Roller in feng-yang county Rice Region. Anhui Agricultural Sciences,1997,17(2):151-152