Research on Agricultural Expert System Based on Fuzzy Reasoning

[1,3] Xin Rui, [1,3] Liu Hong, [1,3] Xu Lei, [2,3] Wang Xinying

[1]Information and Communication Branch Office of State Grid Hebei Electric Power Corporation
[2] North China Electric Power University
[3] xinruicn@qq.com

***Abstract* - Agricultural cultivation is relatively complex, especially the problem of diseases and insect pests were attracted much attention. In agriculture pest expert system, by applying of fuzzy technology, based on the grade of membership threshold select information provided by the user, calculate the similarity by the rule of *Weighted Euclidean Distance*. Present effective disease diagnosis and reliability. On the basis of plant diseases and insect pests knowledge, create disease symptoms and weights database. Considering both positive and negative effects to the disease, endows the user permissions to modify the database. Finally, this paper described the system reasoning process.**

Key words - fuzzy reasoning, weighted Euclidean distance method, expert system.

I. INTRODUCTION

Plant diseases and insect pests of agriculture expert system, also known as the agricultural intelligent system, has become an important technology of agricultural information development. Its main function is to simulate human expert decision-making analysis. Plant diseases and insect pests of agriculture expert system has independent knowledge base, which include knowledge representation, the simulation of expert reasoning, the acquisition and knowledge updating technology .The current plant diseases and insect pests of agriculture expert system can in a relatively short period of time, overall considering agricultural expert knowledge and experiences, according to the users actual situation to make expert level of pests and diseases diagnosis [1].

We have started research of agriculture expert system since 1980s .The first agricultural expert system is fertilization consulting expert system developed The Chinese academy of sciences Hefei institute of intelligent .Since 1990 s, the research of agriculture expert system has moved into vigorous development , such as the 1993 crop diseases and insect pests diagnosis expert system HDS, The High-yield Cultivation dynamic model CGSM of Cotton developed by the Chinese academy of agricultural sciences, etc. Since 1999, China agricultural university has done research for agricultural expert system with combination of 3S and other aspects; Hunan agricultural university developed a rapeseed expert system based on Web. By reason of agricultural pest problem of complicated and changeable, and narrow limitation of traditional agricultural expert system of plant diseases and insect pest database. Therefore, regarding the question of agricultural plant diseases and insect pests, fuzzy reasoning increasingly reflects its unique advantages. With the emergence of Web technology, fuzzy reasoning has rapid development in agricultural applications. Recent years sprung up many agricultural expert system based on Web, typical example such as "Agricultural expert system. Net" established by technology bureau of Hangzhou and agricultural bureau of Hangzhou, Guangxi intelligent agriculture information network, etc.

At present, majority fuzzy reasoning technology systems were based on the similarity, which mainly focus on (definite)positive symptom for certain disease, but not for some negative symptoms of disease occurrence negative role in the equally important position to consider. In addition, the expert system diagnosis results often were given only crops may be suffering from the disease, but lack of the reliability of the diagnosis. To solve these problems, this study considers the positive and negative effect to the disease occurs, the symptoms of the Euclidean distance method is adopted to quantify the reliability of the diagnosis results, making the diagnosis of plant diseases and insect pests of agriculture expert system results more intuitive, clear, and more persuasive[2-3].

II. AGRICULTURAL EXPERT SYSTEM STRUCTURE AND FUNCTION

Expert system is computer software system, by using of the domain expert knowledge to judge and reason in particular domain, solve problems that so far only could solved by human experts. The system is mainly composed of Human-Computer Interface, the interpreter, knowledge acquisition and reasoning machine, knowledge base and comprehensive database. As shown in figure 1.

Human-Computer Interface is composed of user and field expert interface two parts, is a interactive interface between human and system, responsible for accepting user input information, answering or raising user s' questions, outputting system conclusion and explaining the behavior of the system and conclusion.

Knowledge base is used to store from experts on specific areas of expertise and experience, the knowledge comes from the knowledge acquisition module, which is

responsible for presenting the expert knowledge and experience into knowledge base.

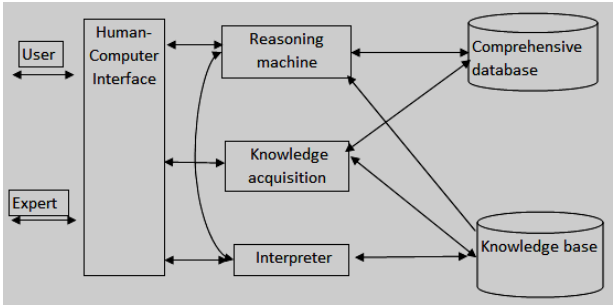

Fig. 1 General structure of expert system

Reasoning machine including reasoning mechanism and control strategy, is searching and reasoning programming module on the basis of knowledge base, it retrieve user input data from comprehensive, search related knowledge in base, and apply fuzzy reasoning rules and some policy to deduce the conclusion.

Comprehensive database is used for storing the initial data, the result of reasoning, control information, the final conclusion, and all the information generated from system operation.

Interpreter is responsible for replying all the questions from users, in the process of reasoning, users through raising "why", "how" and "which" questions, to understand the details and steps of the system operation, verify the rationality of the reasoning or correctness[4-5].

III. THE FUZZY KNOWLEDGE REPRESENTATION MODEL

At now, expert system has many kinds of knowledge representation methods, such as predicate logic representation, produce type representation, the framework representation, semantic network representation, Petri net representation and object-oriented representation, etc.

Fuzzy expert system is used in the process of knowledge representation and knowledge application adopting the expert system of fuzzy technology. In the project study, The system based on the fuzzy reasoning adopts fuzzy production rule to presents knowledge. The premise of fuzzy production rules is fuzzy propositional logic combination, as a condition of reasoning, the conclusion is the result of fuzzy proposition, all the fuzzy degree of proved fuzzy proposition, are represented by fuzzy membership function. The fuzzy production rule is the traditional production rule "IF conditions THEN action (or conclusion)" fuzzily processed, the fuzzification can be from several aspects: conditions, action, or conclusion fuzzification, set up regular fuzzy membership functions rules (or fuzzy degrees) λ. Fuzzy production rules are represented as

$$R_{K}: IF\ X_1(\omega_{K2}) \wedge X_2(\omega_{K2}) \wedge \ldots \wedge X_n(\omega_{kn})$$
$$THEN\ Y(\lambda) \quad (k = 1,2,\ldots m)$$

RK presents K th rule in rule base; *X1* ～ *Xn* presents N fault premise; *Y* presents accident diagnosis conclusion; *ki(i= 1,2…n)* is fussy weighted factor, standard for the degree of each fault premise, $0 \le \omega ki \le 1; \lambda(0 < \lambda < 1)$*i*s rules activation threshold value; *M* is the total number of rules in the rule base. It could be understand as when the above comprehensive matching degree is greater than or equal to the threshold of the lambda *X,* then the accident may occur[6].

Setting up fuzzy membership degree is an important work in fuzzy reasoning, the fuzzy theory adopted the value between "0" and "1" to describe a number of an element in a certain degree of belonging to a certain collection. The way to determine membership degree has comparative sorting method, expert evaluation method, fuzzy statistics method, concept expansion method, etc., in the study of project by using expert evaluation method, each function membership degree is directly given by experts according to the experience, form the membership table, which is accurate. When computer processing fuzzy reasoning, first to receive evidence from the user interface and corresponding fuzzy words, such as "very" "very" "slight" and so on, and then detected membership degree of fuzzy words by fuzzy attributes list, thus come to a conclusion by reasoning[7-9].

IV. FUZZY REASONING METHOD BASED ON KNOWLEDGE BASE

In the real world there are a lot of fuzzy phenomenon which is difficult to accurately describe in mathematical way, such as: "good" and "bad", "fit" and "relatively ideal" and other concepts, and the emergence of fuzzy mathematics well solve these problems. It is theoretical basis for fuzzy reasoning, fuzzy mathematics is a new branch of mathematics. Its birth sign is a professor Chard of university of California Chad written “Fuzzy Sets “in 1965, the fuzzy mathematics satisfactorily solved many mathematical helpless situation, brought new method to research complicated problem which is difficult to use accurate mathematical describe. Apply it to the expert system for plant diseases and insect pests, formed the plant diseases and insect pests of agriculture expert system based on fuzzy reasoning [10].

Plant diseases and insect pests of agriculture expert system based on fuzzy reasoning is able to compare user reflecting issue with database knowledge, select, modify, replenish, selective use of the database knowledge, diagnosis and present reliability. In recent years, with the fuzzy mathematics is gradually widely applied to various

fields, the fuzzy technology has realized rapid development. Due to the description, the way to solve the problem of fuzzy reasoning is close to human thinking, meet users various complicated practical requirements on expert system, so that can reduce the precision requirements of knowledge description, improve the diagnostic efficiency and improves the quality of diagnosis, knowledge update quickly [11].

A. Knowledge Representation of Fuzzy Reasoning

By looking for agricultural pests information and sum up the experiences of experts, and adopts the fuzzy reasoning knowledge representation as follows.

Set up disease symptom fuzzy sets for various diseases. Disease knowledge represents by using sequence-mate notation:

A＝｛(x1，A（x1）)，(x2，A（x2）)，…，(xn，A（xn）)，(y1，A（y1）)，(y2，A（y2）)，…，(ym，A（ym）)…｝

weight set for each disease：*W=（w1，w2，…，wn，w'1，w'2，…，w'm）*

The diagnosis result set：Diagnose=*（R，I，M）*

Among them，A represent certain disease or pets；*xi（i=1,2,…,n）*represents different symptoms of database that has positive function to A occurs；*yj（j=1，2，…，m）* represents different symptoms of database that has negative function to A occurs；*A（xi）(i=1，2，…，n）[or A（yj）(j=12，…，m）]*symptoms under test, relative to A corresponding symptoms *xi (or yj)* membership degree, is a fuzzy description of symptoms under test belongs to the symptoms of xi (or yj)degree, value*[0，1]*。*wi（i=1，2，…，n）* represent weight relation between xi and A, Xi to A approval degree；*w'j（j=1，2，…，m）* represent weight relation between *yi* and A, *yj* to A disapproval degree.

Take user selective symptom and database of each symptom to conduct fuzzy reasoning, if reasoning successfully then returns diagnosis result: Diagnose = *(R, I, M)*. *R* represents the reliability of user's choice of symptoms was diagnosed with A; *I* represent symptom A's introduction, including main symptoms, causes, the main distribution area, etc; *M* A method of prevention and cure.

In order to eliminate some interference factors, adopt filtering method. When users choose symptoms, setting value of membership degree *λ1*, only consider the input symptom its membership degree less than the *λ1*.

B. The Working Process

Fuzzy reasoning process is the core of plant diseases and insect pests of agriculture expert system, which could simulate experts thinking process, conduct fuzzy reasoning, quickly given satisfactory result, work flow chart shown in figure 2.

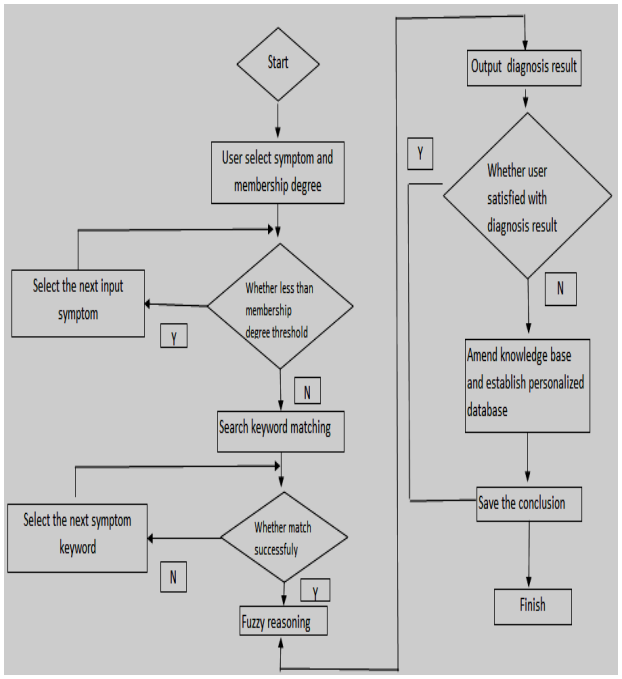

Fig. 2. Flow chart of agriculture disease and pet expert system

First, the similarity of user's selective symptoms and all symptoms under test, which namely membership degree. Then, use the symptoms as keyword searching in the database. According to the membership degree threshold, do screening for the selected symptoms, the membership degree less than threshold symptoms are not taken into consideration. By means of fuzzy reasoning get diagnosis result and reliability of symptoms under test.

Finally, if users are not satisfied with the diagnosis, through the user name and password authentication, the user will receive certain privileges to modify, add, or remove symptoms and weight in the database. System will save the user's modified content, establish the individualized diagnosis system. Administrators regularly check the user's modified knowledge in personalized database, apply the reasonable modification into the database.

C. The Fuzzy Reasoning Process

At present, fussy reasoning is mainly conduct by calculating the similarity of input symptoms set and database symptoms set, its methods mainly include close

degree, semantic distance, similarity and so on. According to the characteristics of the plant diseases and insect pests of agriculture expert system knowledge, this study adopts weighted Euclidean distance method to calculate the similarity.

After user select symptoms and relative membership degree, the fuzzy reasoning process is as follows:

（1） Found out all the symptoms of A disease，include all positive symptoms *xi（i =1，2，... ，n）* and negative symptom *yj（j =1，2，... ，m）*, in the form of A vector to establish A symptoms set:

A0=（x1，x2，...，xn，y1，y2，...，ym）

Assign positive symptom *xi（i=1，2，...，n）* as 1，negative symptom *yj（j=1，2，...，m）*as 0. *A0=（1，1，...，1，0，0，...，0）（n 个 1，m 个 0）*

（2） The user to select symptoms after keyword matching, find meets the requirement of A0 symptoms. According to the user's selective membership degree to establish vector symptoms set B0 for symptoms under test

B0＝［A（x1），A（x2），...，A（xn），A（y1），A（y2）...A（ym）］

Membership degree present by symptoms occur frequency［8］:

$$A(x_i) = f(x_i) = \frac{times(x_i)}{T}$$

T: The total number of plants under test; times (xi) : the quantity of plant to be tested showing symptoms of xi; F (xi) : the frequency of plant to be tested showing symptoms of xi

According to the setting membership degreeλ1, amend B0

$$A(x_i)\begin{cases} A(x_i) & 当\ A(x_i) \geq \lambda_i \\ 0 & 当\ A(x_i) < \lambda_i \end{cases} \quad (i = 1,2,...n)$$

$$A(y_i)\begin{cases} A(y_i) & 当\ A(y_i) \geq \lambda_i \\ 0 & 当\ A(y_i) < \lambda_i \end{cases} \quad (y = 1,2,...m)$$

(3) Using the weighted Euclidean distance method to calculate similarity degree of two fuzzy sets.

Call the symptoms of A weight set: *W = (w1, w2,..., wn, W '1, W' 2,..., W 'm)*

Calculate A symptoms set vector A0 and disease symptoms set under test vector weighted Euclidean distance:

$$d(A_0, B_0) = \sqrt{\sum_{i=1}^{n} w_i (1 - A(x_i)^2 + \sum_{j=1}^{m} w^y{}_j (0 - A(y_j))^2}$$

The relative European weighted distance of two fuzzy vector: τ (A0)

$$B_0) = \frac{d(A_{0,} B_0)}{\sqrt{\sum_{i=1}^{n} w_i + \sum_{j=1}^{m} w^2{}_j}}$$

The similarity of two fuzzy vectors：*C （A0，B0）＝ 1-τ（A0，B0/）* Namely the reliability of symptom to be tested was diagnosed with A

Obviously, if *B0 = (1, 1,..., 0, 1,..., 0) (n-1, m- 0)*, mean B0 contains all the negative symptoms to A and the membership degree is 1, and does not contain any negative symptoms to A. under this circumstance: *d (A0, B0) = 0, tau (A0, B0) = 0, C (A0, B0) =* 1.B0 is completely in conformity with A0, both similarity is 1, for the reliability of disease was diagnosed with A is 100%.

On the other hand, if *B0 = (0, 0,..., 0,1,1,..., 1) (0-n, 1-m)*, mean B0 does not contain any positive symptoms to A, contains all the negative symptoms to A and the membership degree is 1.under such circumstance: *d (A0, B0)* reach the maximum, and *τ (A0, B0) = 1, C (A0, B0) = 0.*Namely B0 has nothing to do with A0, both similarity is 0, for the reliability of disease was diagnosed with A is 0%.

It is clear that user's choice of symptoms set and A set of symptoms more similar, the A0 and B0 two vectors corresponding element more close, the higher the similarity, the higher reliability are diagnosed with A. The diagnosis result is in line with the actual situation.

(4) If users are not satisfied with the diagnosis, it could amend A database knowledge.

V. RESULTS AND DISCUSSION

Plant diseases and insect pests of agriculture expert system select the object-oriented knowledge representation method, which conform to human habitual

thinking, can express the expert knowledge at different levels, with significant flexibility and superiority. In addition, adopted the "browser/Web server/database" three layers of network structure model, formed a complete set of network system, realized the knowledge classification storage, system management, maintenance, information query, data processing, and other functions.

In the face of numerous complex agricultural plant diseases and insect pests, applying fuzzy reasoning into agricultural expert system, formulated the SQL knowledge storage, membership threshold is adopted to improve the information filtering. During the fuzzy reasoning process, take positive and negative symptoms effecting disease into consideration, using evaluation method of weighted Euclidean distance is straightforward, give diagnosis as well as reliability. Especially for the formulating user personalized database, the user is not only the system users, but also knowledge update participants. Under the premise of guarantee database security, to meet the special needs of different users, reduce the administrator workload of collecting data of plant diseases and insect pests and update the database.

Practice has proved that fuzzy reasoning agricultural expert system by using the weighted Euclidean distance method could give accurate and comprehensive diagnosis in very short period of time. System owns following advantages: easy to operate, highly optimized for general use, a small amount of calculation and good for promotion on the Web.

VI. CONCLUSION

As the research hotspot of artificial intelligence, expert system has been widely applied to various fields of production and living. At present, the study of the fuzzy mathematics theory is in the leading position, there are unique characteristics in practical application. Among them, the agricultural expert system based on fuzzy reasoning as a typical, practical application of fuzzy mathematics has fast inference ability and high efficiency to deal with problems, which could effectively lessen the load of the knowledge collection, reduce the precision requirements of knowledge description. For different user specific agricultural pest problem, recommend with expert level of diagnosis and prevention proposals. With the development of network information technology and 3S technology, the continuous improvement of plant diseases and insect pests of agriculture expert system will promote the development of agricultural information development, provide strong support for our country agricultural production.

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